The Welding Engineer

Edited by L. B. Mackenzie

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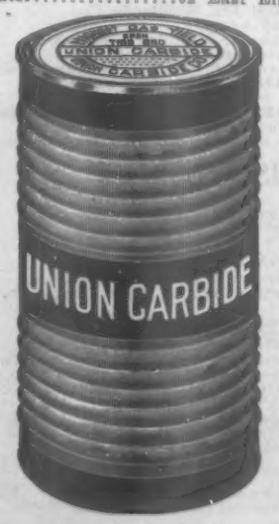

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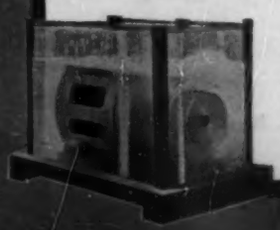

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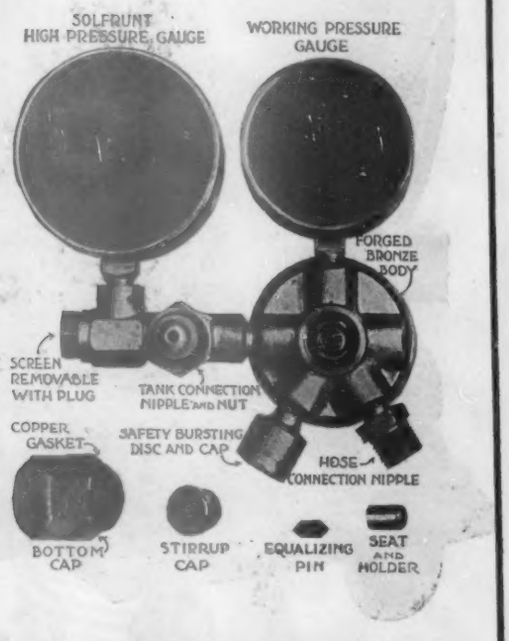

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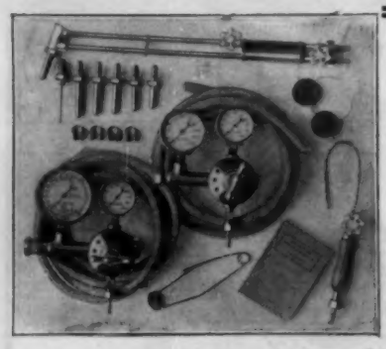

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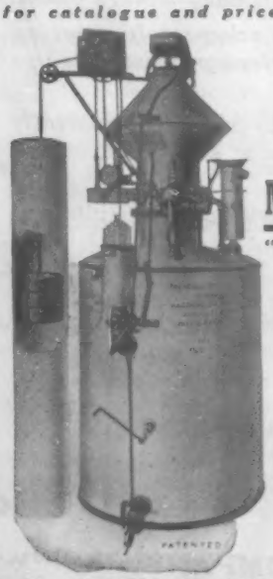

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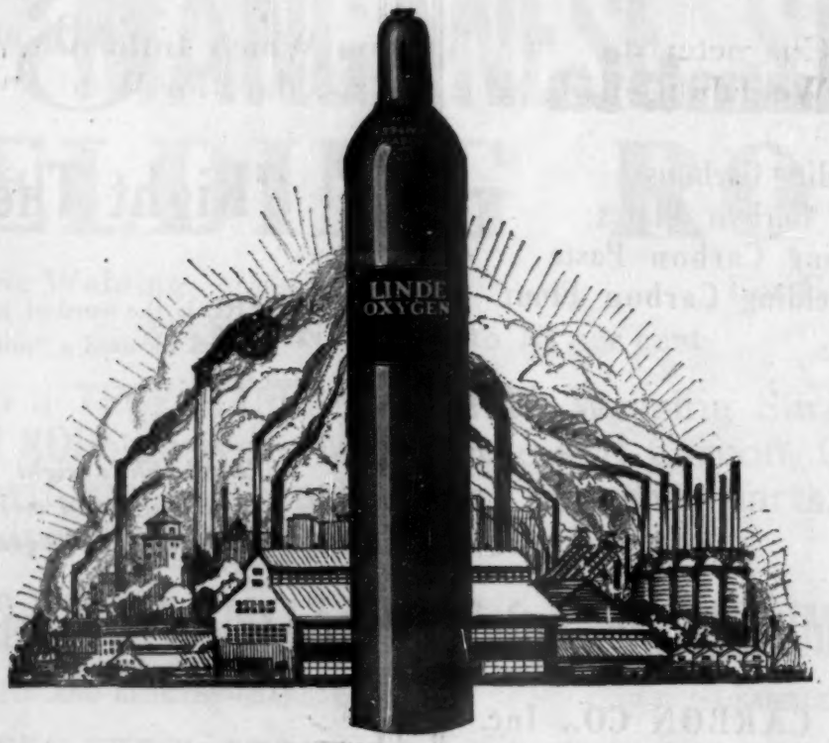

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ARC WELDING OF CAST IRON*

Characteristics of Cast Iron Which Influence Its Weldability and General Procedure for Welding It

By A. R. Allard†

EVERYONE familiar with the merits, as well as the limitations, of applying the electric arc welding process to cast iron and obtaining good welds recognizes the need of a better understanding of the methods of applying this process to this class of work.

Certain fundamental facts concerning the metal, its characteristics, constituents and their relation to welding of cast iron, must be thoroughly understood in successfully developing, supervising and applying electric welding to cast iron if satisfactory welds are to be obtained.

The discussion following points out the most important of these points in a clear, non-technical manner so that one need not be versed in metallography to comprehend and grasp the discussion and conclusions.

Cast iron which comes to the attention of the shop man is made of melting pig-iron and pouring it into molds which form it while molten into the desired shape or casting. Of all commercial products of iron, cast iron is the least removed from the original ore. It retains more nearly the physical and chemical characteristics of the ore and is the product of the first refining process. It requires extensive processes to refine the ore to the stage of commercial steel. Chemically pure iron or ferrite is the highest stage of refinement and is only a laboratory product. It contains no impurities, such as carbon, silicon, sulphur, manganese or phosphorus. Commercial cast iron contains all these impurities in varying amounts, as well as other less important ones. The effect of these impurities on the cast iron, and the physical characteristics, due to their presence, must be carefully studied by the welding engineer.

Carbon is present in cast iron in amounts varying from 2 per cent upward, an average sample containing approximately 3 per cent by weight. The relation of carbon content of cast iron to welding conditions is probably better understood when measured by bulk rather than by weight. The quantity, as stated in any analysis, is by weight and may be converted into an approximate measurement of bulk by multiplying by 2¼. About 7 per cent of the bulk of ordinary cast iron is made up of carbon.

Carbon, which is ordinarily considered as infusible, has the property of readily dissolving in molten metal at about 2300 deg. Fahr. when found in cast iron containing 3 per cent carbon. At this temperature all of the carbon present has combined with the molten metal to form a mixture of carbon and iron. We now say that the carbon is in the combined form, or that we have a mixture known as iron carbide. In order to retain the carbon and iron in the combined state it is only necessary to cause the molten mass to solidify or chill instantly by bringing it into contact with water, a cold mold, or an iron chill, either of which will conduct the heat from the mass with varying degrees of rapidity depending on conditions.

The retaining of the relation between the two substances is dependent upon the speed with which the heat is removed from the mass. When a specimen of metal cooled in a chill is examined, a substance quite different from cast iron and resembling more closely a piece of steel is found. A fracture shows a silvery, fine-grained metal of great strength, but extremely hard and brittle, the greatest hardness being accompanied by maximum brittleness, and each dependent upon the rapidity of chilling. This material is what is known as chilled cast iron and will require remelting or extensive annealing to effect a change to cast iron. It requires from one to three days and often longer to anneal even small sections of chilled iron.

If, instead of chilling the molten metal, we go to the other extreme and cool it as slowly as possible, it will be found that the carbon has separated from the iron into the flaky state known as graphite. This graphite cast iron represents the softest, though the weakest, state of cast iron and is easily cut or machined. It is noticed when cutting or filing that there is a black dust present which readily soils the hands. This dust is carbon dust from the casting. A sample of this graphitic cast iron shows very closely the proportion which exists in the mixture of carbon and iron.

Between the two extremes of chilled cast iron and graphitic cast iron we have cast iron which is partly graphitic and

Fig. 1. Characteristics of Cast Iron Welded by the Carbon Arc Method. Note the difference in grain structure between the chilled cast iron and the original cast iron. Chilled section is full of gas pockets and cracks, also extremely hard and brittle.

partly combined carbon. The usual type of these castings contains 0.25 to 1.50 per cent combined carbon and the remainder as graphite or free carbon.

Silicon (0.50 to 3.50 per cent) is found in cast iron and in certain amounts aids the formation of graphitic cast iron, however the addition of silicon beyond certain fixed limits has an effect similar to that of carbon. An example of high silicon cast iron is found in castings of certain electrical apparatus, the iron of which cannot be cut or filed. Silicon raises the melting point of iron. It also volatilizes readily.

Sulphur (less than 0.10 per cent) reduces the fluidity of cast iron and promotes unsoundness except in cases where the molten metal is chilled readily enough to prevent segregation of masses of it.

Phosphorus (up to 1.50 per cent) increases fluidity and brittleness of cast iron. It also retards the absorption of carbon by the molten iron.

Oxygen breaks up the graphite of cast iron.

We have previously considered three grades of cast iron as represented by the state of the carbon: (1) Wholly carbide; (2) wholly graphitic; (3) partly combined carbon and partly graphitic or free carbon. Consider now the formation of 1, 2 and 3 in the light of additional knowledge of the other constituents of cast iron.

1—White cast iron (combined) (wholly carbide), which is hard and brittle with a fine-grained structure like steel, may be produced by—

*Paper read before American Welding Society, Pittsburgh Section, Nov. 28, 1921. Photographs by courtesy of Westinghouse Electric & Mfg. Co.

†Research Engineer, Westinghouse Electric & Mfg. Co.

(A) Quick cooling through and below the point of solidification.
(B) Presence of much manganese.
(C) Absence of silicon.

2—Gray cast iron (graphitic), which is soft, easily cut and has a structure of iron interspersed with flakes of graphite or free carbon, is produced by—

(A) Slow cooling through and below the solidification point.
(B) Presence of silicon in correct amount.
(C) Absence of manganese.

3—Cast iron between these two stages is dependent on—

(A) Rate of cooling.
(B) Silicon content.
(C) Manganese content.

Present Arc Welding Methods

Carbon arc welding is probably the oldest, and easiest in point of manipulation, of the arc methods of welding in use on cast iron. It consists of drawing an arc between a carbon

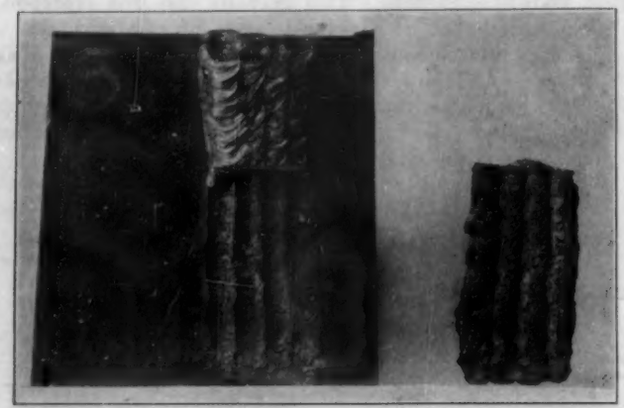


Fig. 2. Characteristics of Cast Iron Welded by the Metallic Arc Method. Note the ashy white appearance of the residue which accumulates between the casting deposited metal. This residue prevents the amalgamation of the metals at the line of fusion. The quantity of this residue is dependent upon the physical condition of the cast iron. Note also the gas pockets in the deposited sections.

pencil and the cast iron part, causing the metal of the casting and the filler rod to become molten at the point of heat application.

Cast iron which melts at 2300 deg. Fahr. and vaporizes at 3300 deg. Fahr becomes very fluid under the heat of the arc, so that practically the only position in which this method can be used is in welding on a horizontal plane and on metal of sufficient thickness to prevent the intense heat of the arc from melting through. Sometimes a backing of refractory material is built about the work to facilitate the operation of welding.

Various metals have a characteristic known as the critical welding heat, at which point the metal suddenly changes from the plastic to a fluid state and above which the further application of heat for extended periods causes burning of the metal. From the point of critical welding heat, pure iron is more easily welded by the arc methods than any other metal. Welding becomes more difficult with increasing amounts of carbon until the point of carbon content is reached which produces cast iron.

Cast iron, when held at a red heat for long periods, will deteriorate, causing it to warp and crack, and if held at high temperature will soon decompose to the point of worthlessness.

When the carbon arc method of welding, as described, is used, the metal is quickly brought to a molten state at the surface, and at this heat the carbon of the metal is dissolved in the iron. When the arc heat is removed the cold sections of the casting quickly conduct the heat from the molten section, causing it to chill rapidly with the attendant formation of chilled cast iron. (Fig. 1). This is exactly what takes place when pouring molten iron into a chill.

Metallic arc welding is another arc method used quite extensively for certain applications. In this method the arc is drawn between the cast iron and a steel wire electrode, causing the steel wire to melt and be deposited in the section of the cast iron melted by the heat of the arc. The steel thus unites with the cast iron by various degrees of contact, adhesion or amalgamation, as the case may be. Because of the doubtful nature of the union between the two metals it is customary practice to insert steel studs or pins into the cast iron, in order that the steel filler material may unite with them, thus anchoring the steel to the cast iron (Fig. 6). Additional strength, due to whatever fusion is obtained between the original casting and the added metal, and the ease with which close contact is made with irregular surfaces of the casting, thus eliminating the work of preparation, represents the advantages of this method of welding over repairing by bolting a plate to the casting. When this method of welding is used on containers for steam, liquids, etc., the seams or edges of the weld can be calked to obtain tight joints. This calking is often necessary on jobs of this class.

In welding cast iron by the metallic arc method, using steel electrodes, the fusion obtained between the two metals is dependent upon the state in which the carbon exists. It is proved by experiment and observed in practice that the closer the carbon approaches the graphitic state the poorer will be the union of metals, while the closer it approaches the combined form the better will be the union of metals. This condition is due to the fact that, as the carbon approaches the graphitic state, there is less continuity of the iron matrix and less cohesion between the iron crystals, due to the laminated structure of the graphite particles. In addition to this, the formation of a layer of residue, of ashy or sandy appearance, between the two metals at the line of fusion prevents the union of the metals. This condition becomes more serious as the carbon approaches the graphitic state and is due to the inability of the molten iron to quickly dissolve the graphite flakes, leaving them exposed to the action of the arc and oxidation.

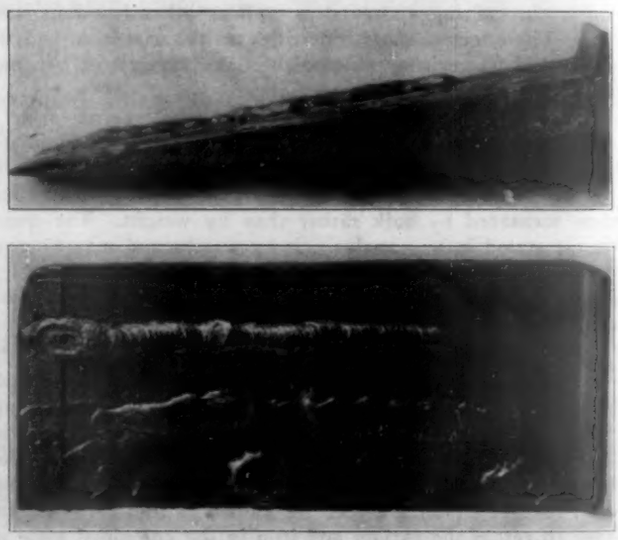


Fig. 4. Characteristics of Cast Iron which Influence its Weldability. The casting was made wedge shape so as to present metal in various physical states. Note the fine grain structure of the iron at the tip and the development of the graphitic conditions which increase with the section. The sections puddled by the application of the carbon arc show good fusion with the fine grained metal at the tip and greater recession from the edge of the original metal as the coarse grained graphitic structure develops. The fusion and penetration shown by the string of metal deposited by the metallic arc is poor in the graphitic iron and increases as the welding progresses into the fine grain section at the tip.

This layer of residue is formed as the steel matrix of the cast iron becomes molten, and in a molten stage is attracted to and unites with the layer of metal already formed and partly solidified. As this movement of metal takes place, due to molecular attraction, most of the graphite which is in the laminated formation is left behind, and, being without its supporting matrix, settles to the bottom of the depression left by the movement of the metal. This deposit or layer

of graphite, being a good conductor of electricity, concentrates the action of the arc, which partly oxidizes it and packs it into a layer with the dirt and oxide, thus forming the layer of residue which prevents the amalgamation of metals as the line of welding is extended (Fig. 2).

The degree of fusion that can be obtained on any piece of cast iron can be foretold by visual examination of a fracture in the material, or by the application of the carbon arc to a small area of the casting. If the metal becomes fluid when the arc is applied, and spreads over the parent metals to the line of fusion, making a smooth appearance and even contact, instead of receding from the parent metal at the edges of the line of fusion as though they were two foreign substances (Fig. 4), good fusion can be expected.

Upon examination of a weld made by the steel metallic arc process, even though good amalgamation of metals has resulted, numerous small gas pockets are found, particularly in the layer adjacent to the casting. These holes are caused by gas formed by the application of heat to the layer of graphite, dirt and slag mentioned, and by the volatilization of carbon and silicon of the cast iron. There is also a tendency for cast iron to absorb moisture from the air upon being heated. This moisture, upon being gasified, may also cause gas pockets or holes.

With this method of welding there exists between the layers of steel and cast iron a hard area which cannot be cut except by grinding it. This area usually consists of a layer of chilled cast iron next to the layer of slag mentioned above, and on the cast iron side of the weld, while on the other side of the layer of slag and adjacent to it there exists a layer of chilled high carbon steel which is formed by the alloying of the molten high carbon metal of the original cast iron with the added steel. This layer of high carbon steel varies in thickness from a very thin layer at the line of slag to the full thickness of the added layer, depending on the character of the cast iron and the depth of penetration secured. It will readily be seen that the deeper the penetration, or depth of cast iron liquified by the application of the heat of the arc, the greater is the amount of molten high carbon metal to unite with the added molten steel. A close inspection of the action of the arc and metals, while the welding is in progress, will show that practically all the molten metal of both the casting and the filler rod unite to form the layer of metal which lies above the line of slag.

Another difficulty in the way of securing satisfactory welds with the metallic arc on some applications is due to the separation and cracking caused by the shrinkage of the molten

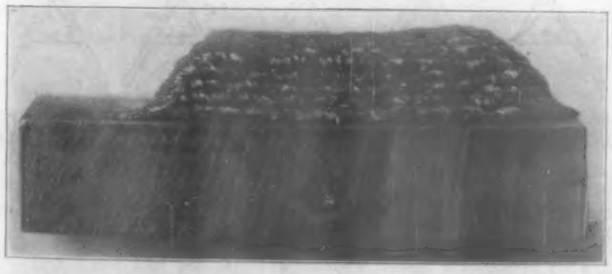


Fig. 5. Steel Deposited by Metallic Arc Method on Block of Cast Iron. Note the separation of the deposit from the cast iron. This is particularly noticeable at the ends of the deposits.

metal upon solidification. The trouble experienced from this cause is often erroneously attributed to the difference between coefficients of expansion of the two metals.

Contraction and expansion, as everyone who has had experience in welding knows, causes more trouble and failures in the welding of cast iron, by any method, than all other causes combined.

Every physical and chemical change in metal is accompanied by stresses set up within the metal. As these stresses exceed the strength of the metal, it is not hard to understand the warpage and breakage caused by this agent in a metal as weak, rigid and brittle as cast iron. When steel or cast iron is subjected to heat it expands as the heat increases until a point is reached just prior to fusion, when the metal assumes its greatest bulk. On cooling, it again increases to its greatest bulk when passing from the molten to the solid state.

In welding cast iron with the metallic arc, using steel filler material, the difference in contraction between the molten added layer and the casting often causes trouble. The strength of the added steel is much greater than the strength of the cast iron, so that the steel, upon contraction, may pull

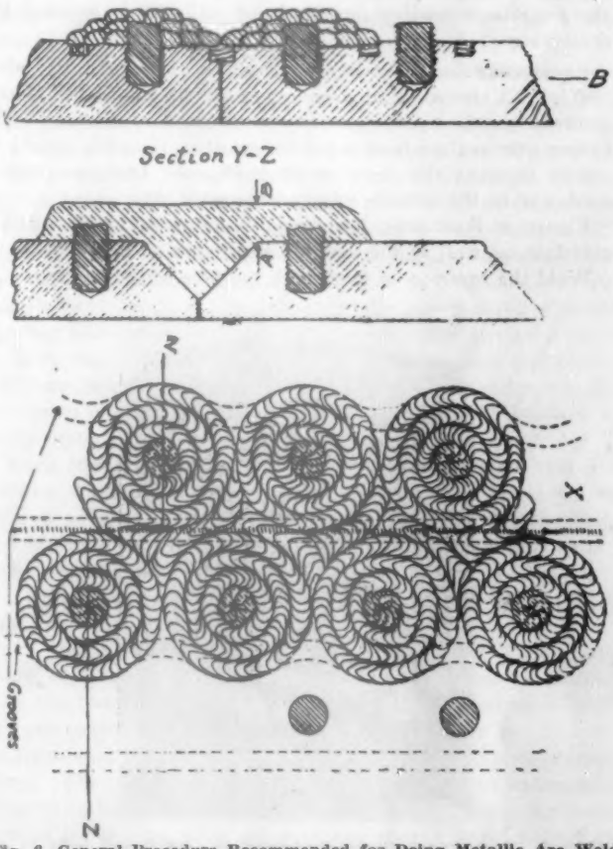


Fig. 6. General Procedure Recommended for Doing Metallic Arc Welding on Cast Iron Parts.

away from the cast iron (Fig. 5), or in some cases, where good fusion of metals has been secured, the cast iron will be fractured. The fact that the separation usually takes place at the line of slag or the point of contact of the two metals is due to poor fusion of metals and to the fact that this is the line of creepage or movement between the metals. Even though good fusion of metals has been obtained, the separation will be in the vicinity of this line and on the cast iron side.

The steel metallic process of welding is the only method adaptable for certain applications. Examples of this are found frequently in castings which permit the use of only a limited amount of heat, and in jobs which require welding to be done by overhead manipulation of the arc. This latter is usually prohibitive in other methods on account of the fluidity of molten cast iron.

The following outline covers the general procedure recommended for doing metallic arc welding on cast iron parts.

In preparing a casting for this process care should be taken to remove all scale and sand by chipping or sand blasting the entire surface to which metal will be fused.

A square groove is chipped along the line of the break or crack. The size of this groove depends upon the thickness of the casting and is usually ¼ in., ⅜ in. or ½ in. square.

The groove is then filled up by welding until it is flush with the face of the casting.

Locate and set the first stud in the casting as close to the

crack as practicable. The location of the stud is determined by the thickness and shape of the casting and the size of the stud. The size and number of studs is dependent upon the volume of added metal required to give the necessary strength Studs should be long enough to extend through the first layer so that good fusion can be obtained between them and the second layer. The studs should be set as close to the edge of the break and to each other as practicable.

Weld around the first stud with a sufficient number of rows of deposit to reach the center of the break, as shown at X in Fig. 6. This procedure will determine the area covered by the metal surrounding one stud and will aid in locating the remaining studs.

Locate and set the necessary number of studs to complete the job. Chip or grind grooves, as shown in Fig. 6. These grooves may be either square or semi-circular, although ¼ in. square grooves are used most frequently. Grooves should be placed between the rows of studs if more than one row is used, and at the outside edge of the weld area.

Figure 6 illustrates the preparation as to grooving and studding, as well as the welding procedure to be followed.

Weld the grooves up flush with the face of the casting.

Fig. 7. Cast Iron Sections—Preheated to 1500°F and built by the Metallic Arc Process of Welding, using a Cast Electrode. The section was cut with a hack-saw to show that it could be easily machined, and was then broken to show the characteristics of the weld and original metal. Note the dense fine grain structure of the added metal and the graphitic structure of the original casting. The added material is stronger than the original casting and is easily machined.

Weld the first layer around all studs as was done with the first stud. The outside row of the pads of adjacent studs are not united at this time except where they emerge into each other at the outer circumference.

Weld the second layer around all studs (Fig. 6-B), taking care to make the pads cone shape, so as to leave a "V" to be filled when the pads are united.

Weld additional layers if required.

Unite all pads except at the line of the break, taking care to leave this operation until the last in order that the greater part of the shrinkage will have occurred before this union is made. In uniting the pads, when more than one layer of deposited metal has been added, it is best to follow the contour of the pads with additional rows of metal as the welding advances from the bottom of the "V" or base of the cones.

Unite the weld at the break, as shown in Fig. 6.

The operation of welding cast iron by the steel metallic arc method should proceed very slowly, with each addition of metal being very small in order that the heat absorbed by the work may be kept to a minimum.

Drilling at the end of the break or crack is optional and not often required, as the casting should never get warm enough to expand and extend the break.

One of the mistakes made in the application of this method of welding is the practice of building up heavy sections or layers of steel adjacent to the cast iron. When good fusion is obtained the section of steel can be easily kept at one-half that of the cast iron section required to give the necessary strength. It is evident that when the stresses are great enough to warp the steel, it will, in most cases, pull from, warp or break the casting (Fig. 5).

The square groove at the break, when filled by welding, closes up the break and offers a projection against which the shrinkage of the added material draws the adjacent sides of the casting, thereby utilizing as an advantage one of the greatest trouble-giving factors encountered in cast iron welding. The other grooves are additional insurance against leakage when welding cylinders or containers for liquids or vapors. They also give additional strength to the welding.

The method of "V'ing" out the casting, as shown at "A" (Fig. 6), was inherited from the practice followed in gas welding and may be followed when welding sections of casting in which the carbon is found to be in a condition which will give good fusion between the casting and the added metal.

The heavy sections of graphitic cast iron usually encountered should not be "V'ed" out, because the surface of the casting, which chills quickly when cast, affords a better quality of metal upon which to weld than is presented as the casting is cut below the surface. As the cut becomes deeper the amount of graphite present in the metal increases. Examination of "A," Fig. 6, Section A-B, will show that no increase of strength is gained by "V'ing" out in cases where the fusion between the metals is poor.

Figure 6-A also shows another disadvantage to the beveling method of preparation. There is without question considerable shrinkage of the steel filler material no matter how carefully the work is done. Reference to the sketch will show that the shrinkage draws the bevels of the casting against the beveled boss of the added section, with the result that the pressure exerted tends to lift the steel section from the casting, and this, in fact, takes place in many cases.

The practice, as outlined, will keep the effect of shrinkage strains to a mimimum by affording a procedure which will keep the work cool, and by affording means of equalizing, balancing and taking advantage of the stresses which cannot be eliminated. The use of small wire, as low current as permissible and straight line welding without weaving or oscillating of the steel electrode will also assist in keeping the work cool and minimizing the stresses.

Fig. 8. Examples Showing Stresses Set Up in Castings During Welding.

The procedure most widely understood has been outlined. The ideal procedure would result in welds which would have the following characteristics:

(1) Good amalgamation of metals.

(2) Prevention of chilled metal at the line of fusion or in the weld.

(3) Provision for accommodating expansion in the casting.

(4) Elimination of gas pockets and holes.

(5) Same coefficient of expansion between the casting and the added material.

(6) Deposition of added material which will approximate the characteristics of the original casting.

(Continued on page 40)

The Insurance Man and Acetylene*

Problems Which Confront the Insurance Inspector in Connection with Oxy-Acetylene Installations and Applications

By Dr. A. D. Risteen†

Dr. A. D. Risteen—Mr. President and Gentlemen: I came here with some trepidation, and some of my friends told me to don a full suit of armor before coming and talking to you from the standpoint which I hope to present.

I am to talk about the insurance company's point of view in connection with acetylene. The subject is a large one, and I suspect that writing a book about it might be easier than preparing a short address, properly balanced and adequate to the occasion.

The Insurance Company's Problem

Insurance companies are prominently interested in two fundamental questions about acetylene. First. Is acetylene essentially and necessarily a bad actor like the dragon of St. George, which presumably breathed fire, ate rocks, devastated the countryside and acted in general like the devil that he was; or, may it be a reasonably innocent thing when properly handled, and is it rational to expect that in lighting installations, for example, it need not be any more hazardous than the candles, lamps, electric lights or ordinary illuminating gas, one or other of which we should have to use if acetylene were not available?

That is the first question. Now, assuming that favorable experience of this kind can be realized, the second question is: Will it actually be realized in practice? The two questions are distinct, and, although I believe there is no room for argument about the possibility of handling acetylene with a high degree of safety, what the insurance company wants to know, and must know if it is going to carry on a sound business, is how the thing is actually working out in practice, or is going to work out in practice in the future.

Juggernaut Versus Acetylene.

I should like to digress for a moment and consider the case of Juggernaut. He is a god, worshipped in certain parts of India. A festival is held in his honor at Puri every year, and part of the celebration consists in drawing a large wagon through the public street. There is an old story to the effect that many persons are killed by the wheels of this wagon, and when I was a youngster I saw some horrible pictures showing the "Car of Juggernaut" rolling over men and women and crushing them to death. There is hardly a word of truth in this story. The total distance that the wagon is drawn is less than a mile, and the journey takes several days. This certainly does not exceed the speed limit as we understand it in New York; and any person who tried to be run over by such a car would have to go about the job in a most deliberate and patient way. There are very few deaths indeed from the car of Juggernaut but one occurs occasionally, owing to the fact that the street is packed with dense crowds.

The Juggernaut story grew up before the day of the motor car, and at a time when the death of a person in consequence of street traffic was so unusual that it attracted a vast amount of attention. As time passed we became innured to accidents of this kind, and the terrible and deadly care of Juggernaut would now be considered quite harmless.

It is always the new thing upon which attention is riveted, and it is the new thing that gets undue and often wholly inaccurate and unmerited publicity in connection with any unfortunate results with which it may be associated, or with which somebody may suspect it to be associated.

It isn't so very long ago that electricity was suffering from this lack of mental perspective and pretty much all the fires that occurred were attributed, by the public, to electric wiring, and later, when electrocution first took the place of hanging, quite a number of electrical engineers disapproved of the change because they feared that it would direct attention too strongly to the hazards of electric shock—as very likely it did.

Acetylene is now going through its Juggernaut stage, and its shortcomings are being magnified accordingly. It is not exactly new, but it is being so generally introduced for house lighting and other purposes that attention is attracted to it quite prominently, and the public is inclined to over-emphasize the dangers associated with it, and is also prone, I fear, to attribute to it many evils and unfortunate things of which it is really quite innocent.

Some few of you may remember that the great fire that destroyed Chicago was caused by the Widow O'Leary's cow kicking over a lamp; but most of us have forgotten the fact, and if the fire should occur now the chances are that somebody would try to hang it onto acetylene.

I do not wish to minimize the dangers of acetylene in the least, and in a few moments I am going to review some of them, though necessarily in a superficial way. But before doing so I want to call attention to the fact that in dealing with the hazards that are possibly or surely connected with any one particular thing or operation, it is easy to give the impression that we are dealing with an exceedingly dangerous thing. The true safety engineer does not get this impression because he knows that there is much to be said along the same line in connection with other things that might be used or done in place of the things of which he is speaking. For example, the illumination of isolated dwellings and similar buildings may be accomplished by means of acetylene on the one hand, or by means of oil or electricity on the other; and it would be a serious mistake to assume, just because I am now talking particularly about acetylene, that no comparable dangers exist in connection with other light sources. It ought to be necessary to make such an explanation, but I thought it might obviate possible misunderstandings.

Insurance companies are interested in the properties of acetylene itself; in the generation of acetylene from carbide; in the compression of the gas; and in the possible formation of sensitive compounds with metallic oxides or other substances, as well as in the possibility of poisoning. They are also interested in the containers in which acetylene is shipped or stored; in the problems that arise in connection with transportation and handling; in the fire and explosion hazard that is associated with acetylene when it is used either for illumination or for welding and cutting; in the making of welds of every kind—and most particularly in welds which are likely to be subjected to a considerable tensile stress. Further than this, the insurance companies are deeply interested in the related hazards associated with compressed oxygen.

The Properties of Acetylene

A source of danger that was quite real at one time, but which is now overcome because it is well understood, consists in the fact that acetylene is capable of forming sensi-

*Paper read before the annual convention of the International Acetylene Association, New York City, October 4, 5 and 6, 1921.

†Travelers Insurance Co.

tive compounds with the oxides of certain metals, and prominently with those of copper, lead and zinc. As soon as research had cleared this matter up and showed beyond question what the objectionble metals are, practice in connection with the manufacture of apparatus for handling acetylene was modified accordingly, and at the present time we can dismiss this source of danger from the list of hazards that have to be considered—except that it means that when any part of the apparatus is to be repaired, or any of the joints are to be re-made, the work must be done under the direction of somebody who understands the subject properly.

The fact that acetylene is what is called an "endothermic" gas has often been cited as indicating that it is intrinsically dangerous to handle. The rather forbidding word "endothermic" merely means that acetylene, when formed by the union of the elements composing it, absorbs heat instead of giving it out. This characteristic is possessed by a number of unstable substances, and whenever we meet with an endothermic compound we are naturally and properly on our guard. The fact that it is endothermic raises a question as to its stability, but does not in itself prove anything. Its stability or instability must be determined by experiment. In the case of acetylene a great deal of work has been done in this direction, and it has been found that the instability toward shock that it was feared or suspected that the gas might have by reason of its endothermic nature, actually does exist when the pressure exceeds a certain value; but it has also been proved that below that value the gas is entirely stable. There is no danger at all of spontaneous decomposition, so long as the pressure of the gas is not allowed to become (say) 20 pounds* per square inch greater than that of the atmosphere; and inasmuch as the generators that have been approved by the Underwriters' Laboratories produce the gas at a pressure less than 15 pounds in excess of that of the atmosphere, we can dismiss the possibility of spontaneous explosion through internal instability, unless the acetylene is subsequently compressed in some way.

Time was, when acetylene was stored in otherwise empty tanks at a high pressure, just as we might now store air or carbon dioxide. This, of course, was a mistake. The properties of the gas were not then thoroughly understood, and by compressing it heavily in such tanks it was brought into an unstable condition and a number of serious explosions occurred in consequence.

It was subsequently found, as you well know, that acetone will dissolve many times its own volume of acetylene gas, and experiment showed that a solution of this kind is perfectly stable against shock, and secure from spontaneous decomposition from any other cause. This wrought a revolution in the method of storing acetylene under pressure, and transformed a markedly dangerous practice into one that is admittedly quite safe.

The compression of acetylene, for the purpose of introducing it into acetone-filled tanks, is a special kind of operation which I cannot undertake to discuss on the present occasion. It should be said, however, that the compression can be conducted with reasonable safety, provided the work is done in the right way and under the charge of somebody who knows precisely what ought to be done. One of the main points is, to effect the compression in a sufficient number of stages, and to cool the gas, not only while it is being compressed, but also between the successive steps in the compression process. Compression of acetylene to pressure higher than two atmospheres, absolute, should never be undertaken, under any circumstances, except under the direction and supervision of an expert who undertands all the precautions that must be observed.

We used to be taught that acetylene is quite poisonous, so that serious efforts would be likely to follow the development of slight leaks in piping conveying the gas, but later experiments indicate that this is not the case. If the acetylene is pure, air containing it in considerable quantity can be inhaled, apparently without harm. The danger of poisoning on account of leakage is certainly immeasurably lower in connection with acetylene than it is in connection with the ordinary water-gas that is used in so many of our cities for light and heat. Water-gas contains a large amount of carbon monoxide, which is exceedingly dangerous when present in the air even in small quantity. It forms a comparatively permanent compound with the red coloring matter of the blood, thereby diminishing the efficiency of the blood as an oxygen-carrier, and it also appears to act on the nervous system as a direct and immediate poison. Moreover, water-gas, as usually manufactured, does not have a very strong odor, and a dangerous amount of it may be present in the air without the fact being strongly forced upon our attention. In the case of acetylene, however, a trifling amount of leakage is quite noticeable, on account of the characteristic smell of the gas; and leakage could not fail to attract attention, long before any harm would be likely to come from breathing the air in the room. I do not make this comparison with any thought of disparaging water-gas, but solely for the purpose of emphasizing the still greater safety of acetylene, so far as concerns danger of poisoning through the inhalation of gas-contaminated air.

Illumination

In connection with the installation and use of acetylene lighting systems in residences and other isolated buildings, it is essential to have a good, safe apparatus for generating the gas, and, furthermore, it is essential to handle this apparatus in the proper way. There is no difficulty in getting the right kind of apparatus, because there is in Chicago, as you know, an institution called the Underwriters' Laboratories, which makes a special study of problems of this nature, and sets the seal of its approval upon various kinds of apparatus, after considering them carefully, consulting with various authorities throughout the country, and carrying on as much direct experimental work as may appear to be necessary. If you follow the decisions of the Underwriters' Laboratories, you can hardly go wrong in connection with the type of apparatus that you install.

So far as concerns the management of the apparatus after it has been installed, the case is equally simple. The manufacturers of each type of generator put out definite rules for handling it, and if these rules are observed, there does not appear to be any notable danger of fire or explosion, nor any other danger that is in the least degree likely to bring unfortunate results. The rules that are promulgated in this way are simple and easy to follow out, and the reasons for most of them are fairly evident.

If the apparatus is installed and managed in conformity with the regulations of the Underwriters' Laboratories and the National Fire Protection Association, fire insurance companies as a rule do not charge, for lighting installations using acetylene gas, any higher rate than is charged for the same kind of a building using ordinary city gas. Some companies charge a small additional rate, however, if the generator is situated inside of the dwelling. Others apparently do not make any extra charge, even in this case, provided the apparatus is of an approved type, and is installed in an approved way. It is not easy to tell all the facts about fire-insurance rates in a single statement that will be both simple and accurate, because the making of these rates is a somewhat complicated problem, which involves other things in

**This was originally stated as 25 pounds by Dr. Risteen and was afterwards modified to read "20 pounds." See discussion on this point immediately following conclusion of Dr. Risteen's paper. —Editor.*

location of the plant; but the account of them that I have given is substantially correct. I ought to add, however, that the amount of carbide that may be kept in storage is usually limited under the policy, and the nature of the carbide containers is also specified.

The general view of the insurance companies with regard to acetylene illumination agrees, I think, with the view expressed by the Farm Inspection Bureau of the Co-operative Fire Underwriters' Association of New York State. Namely, "Acetylene gas is a very satisfactory and economical light, and perfectly safe when properly installed. It is also very dangerous when carelessly installed by incompetent persons addition to the installation and management of the apparatus. For example, the rates vary somewhat with the geographical not familiar with standard requirements." But I should like to qualify this verdict in one respect. It refers only to the installation of the plant, and I feel that even though the installation be ideal and perfect, reasonable emphasis should also be laid upon the exercise of ordinary care and intelligence in the operation of the apparatus and (as already noted) upon repairs and adjustments being made by persons who understand what is permissible in this connection, and what is not. I have in my house a quarter-in-the-slot gas meter, through which I get ordinary city gas. If I forget to keep this meter duly fed with 25-cent pieces, my gas stove will presently go out, and if I then go downstairs and put in another quarter without first turning off the gas at the stove, I shall certainly get a good deal of free gas in my kitchen, and an accident may occur in consequence. Moreover, if somebody had gone to sleep in one of my rooms and left a gas-burner lighted, my action might cause the death of that person. We have to handle every kind of apparatus with a reasonable amount of common sense, no matter what method of illumination is used; but I am convinced that the dangers associated with acetylene are no greater, at all events, than those pertaining to the use of ordinary city gas, and that they may be avoided with equal ease and certainty.

Welding

The casualty insurance companies are far more keenly interested in oxy-acetylene welding than they are in acetylene illumination, and that fact must be my excuse for talking about it at some length. Oxy-acetylene welding has become so common, at the present time, that it is a small town that does not contain at least one shop in which work of this kind is done, and the jobs that are turned out are of the most varied nature imaginable, not only in range of application, but also in quality and strength. Much of this welding is to be used in places where no special harm would result, even if the welds should fail; and work of this order may be fairly done, I suppose, by any intelligent person who has the necessary apparatus, even though he may have no very profound knowledge of the welder's art. But there are many other kinds of welds, the making of which calls for skill of the highest order, if disastrous results are to be avoided. I am thinking, now, of welds in parts that have to support heavy stresses, either continuously like the shell plates of a steam boiler, or cyclically like the arms of a power-transmitting pulley, or intermittently and irregularly like the tension members of the trusses of a railroad bridge. The insurance people are intensely interested in work of this nature—that is, in the quality of the work after it is done, rather than in the hazards involved in its performance. In fact, there are comparatively few jobs of work of this specially-important kind that the insurance companies will countenance at all, and their unreadiness to approve of welding in such cases has led some critics to consider them unprogressive, or at least ultraconservative. I suppose, in fact, that one reason why I am here today is, that you want to see what one of these ultraconservative fellows can find to say, to justify his backwardness on this very point.

Well, here is the answer, so far as I have been able to frame it up in a reasonably small space.

In the first place, there are many local laws and ordinances, or other regulations having similar legal standing, which prohibit the welding of certain classes of work; and the insurance companies have to abide by every regulation of this sort, whether it appears to them to be well-founded or not. The insurance company is not invited to express its judgment in such cases. It is merely told, in common with the rest of the public, that certain things are "not done."

Second, various codes, that have been drawn up in final or tentative form by engineering societies or other agencies worthy of serious attention, prescribe certain things in connection with welding, and prescribe others; and although the insurance companies are not legally obliged to conform with codes of this kind that have not been specially sanctioned by law, yet it appears to be the part of sanity and wisdom to be at least as conservative as these codes require, because they are put out by men who are supposed to be competent to deal intelligently with the subject, and who have presumably given it due consideration and discussion. An insurance company could hardly refuse to sanction any code coming from a body of men of good standing in the engineering and technical world; that is, it could hardly assent to any welding operations that a code of this kind might forbid, though it could with propriety carry the restrictions or limitations still further, if it chose to do so. I believe you will all agree that the position of the insurance company is perfectly sound, up to this point; and I suspect that some of you welding experts might even be disposed to go further, and refuse to sanction certain of the things that some of our present codes might permit.

I come, now, to the point where the insurance company and the welder are likely to disagree. The welder may turn out what has every appearance of being a perfect job, and yet if the failure of his work would be likely to be attended by consequences of a grave kind, the insurance company may refuse to give its sanction on the ground (1) that there is no satisfactory way of proving that the weld has the assumed strength, and (2) that the history of welds, in the past, has been such that an attitude of incredulity is not only pardonable but essential to sound and safe practice. To speak in the vernacular, the insurance company "has to be shown," and it places the burden of the proof squarely upon the welder who did the work and who asserts that the job has a specified strength. This position does not apply to gas-welding alone, be it understood. It is the attitude of the insurance company toward electric welds also, and until some more definite answer can be given to the insurance company's objection, the situation is likely to remain just as it now stands.

Let us turn the thing around and look at it another way. If a weld of the kind under consideration should fail, it may (we will assume) cause two or three deaths, and in addition it may cost the insurance company $50,000 or $100,000 or some other large sum. What does it cost the welder? He would naturally be extremely sorry for the event, and amazed to find that this judgment was so badly at fault; but that would not restore the lives that had been snuffed out, nor would it in any way lessen the bill that the insurance company would have to pay. And even if there were a legitimate and proper way, by re-insurance or otherwise, for the insurance company to avoid the heavy financial loss, the status of the case would not be materially improved. Our obligations toward the public are moral as well as legal and financial, and few companies would be willing to adopt an evasive course of this kind, merely to escape or reduce the payment of money in connection with a risk which in itself was felt to be of a doubtful or unapproved nature.

(Continued on page 28)

WELDING CRANK SHAFTS

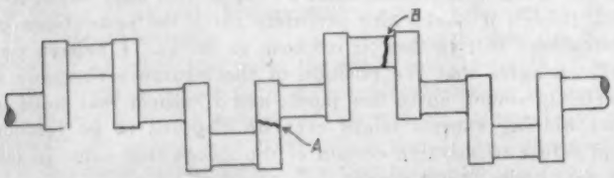
Wrist-Pin Breaks Repaired by "Moving the Weld" Away from the Machined Surface

Seattle, Wash.,
Thursday.

Dear Ed:

Well, here I am, back in the States once more and maybe I'm not glad. Mind you, I'm not saying that Canada hasn't its redeeming features but all the same it feels much more satisfactory to be back where old glory waves.

From the Yankee's way of thinking the world seems to run backwards the minute he hits Vancouver; I say the minute he first lands, for after a half hour has elapsed, and, going on the assumption that he possesses any kind of a thirst, Vancouver has his whole hearted O. K. What, then is wrong with the village? I'll tell you Ed. They run everything wrong way to. Everything, as far as traffic is concerned, runs on the left hand side, automobiles, street cars, bikes, et al. In crossing the street you think a street car is going



(A) Represents Break Through Cheek. (B) Represents Break Through Wrist-Pin. (Machined Surface)

the other way, when bang! all of a sudden its right on top of you. So much for Vancouver, it was a great time while it lasted but here we are, back where the grass grows green even tho it be dry.

Welding? Oh yes! I did come across one especially good stunt up there. It was on welding crank shafts and I know you'll fall for it hard 'cause I've heard you cuss too many of them to know different. This, bear in mind, isn't going to cure all your ills or anything like that but if it don't start your "thinking apparatus" along a new line I lose the fur-lined bath-tub. As near as I can remember I made a few notes and some sketches. They don't seem to be in my pockets; just wait a minute and I'll look in my bag.

They're found Ed, so all's well. I stumbled on to this one something as follows: After knocking around a bit it appears that I landed in a shop which, while it wasn't Vancouver's largest, had Canada's best welder in it and although I can't just remember his name, we got to be pretty good friends. Guess he was a fairly good welder at that because after we became acquainted I started to tell him about some of the stunts I had picked up for you during my various jaunts, but everything I told him he already knew.

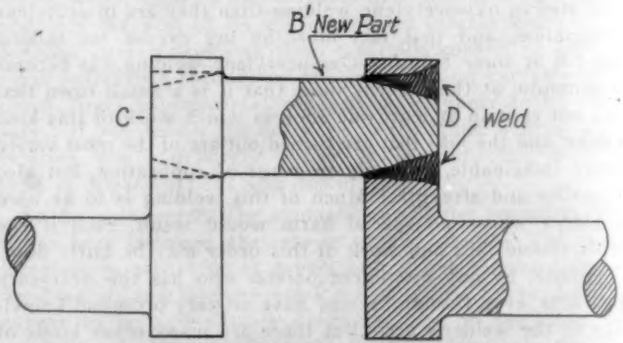
After a bit he asked, "Have you ever picked up anything in the way of crank shaft welding!"

Ed! right away I sobered up because I knew that was one thing you were a little weak on, so I bid him tell all he knew.

"Crank shafts are peculiar things," he started, "and if your friend hasn't had very good success with them, perhaps it won't be amiss to tell him about some of my experiences. Now I'm not saying that every broken crank shaft can be welded satisfactorily because in some cases it's a crime to even touch them; not from the welding stand point but rather on account of one feature which I'll point out immediately. When a shaft of this kind is brought to a welder the very first thing he should find out is whether the break was occasioned fatigue or some external force. By fatigue we mean carbonization of weakening of the metal. If this is the cause of the break there is a pretty good chance to do the welding and have little trouble in truing the shaft up later. But if fatigue was not the cause and it came from some external source such as the breaking of a connecting rod or a jam of some kind, then watch out, for the chances are that in addition to being broken, the shaft is also "sprung." such being the case, more depends upon the success of the job than the actual welding for unless a job is restored to a usable condition the welding is not considered a success."

"That would be much like the one an old doctor perpetrated the other day," I ventured, "he said that his operation was very successful but his patient died."

"You have the idea all right," he continued, "you see I always figure that it is much better to have fore-sight than hind-sight. If a little thought is given each job before starting, providing its not of the ordinary run, better results are bound to follow and many times the welder will discover things before he starts that might be credited to his welding if they were not pointed out to the owner beforehand. Take these crank shafts we are talking about for an example. If the shaft is badly "sprung" it would seem sort of foolish to even consider welding it, unless a new one could not be found or the owner was willing to take a long chance, for a crank shaft must have its bearings in perfect alignment or there will be trouble. Now the weld may be made in good style, providing its in a weldable place, but the straightening is what takes the time. You can believe me or not, but I'll tell you I spent as much as three days some years ago in trying to true up a shaft I had welded and then I had to give it up. Of course, I've improved a lot since then.



(B) Shows How New Wrist-Pin Is Made and Welded in Place

"Just one moment if you please," I broke in, "how about these weldable places you just mentioned. Do you mean that there are some places in a crank shaft that can't be welded?"

"I wouldn't say that they can't be welded but from my experience I find that its not advisable to weld at certain points."

"Let's have them," I said, "I'm rather anxious to know just where they are."

"If you'll just hold your horses I'll come to them presently. First of all I'd like to give you a few 'whys' and 'wherefores' so you can pass them on to that friend of yours. As I was saying, it makes quite a bit of difference as to what caused the shaft to break and usually a pretty good idea can be had as to the approximate cost in case the owner wishes to have the price in advance. This is especially true after a fellow welds a few and has to straighten them.

"Now a shaft will break in either one of two places," he continued, but this statement was too much for me.

"Get out! I've seen them break in a hundred different places, what are you trying to hand me," I broke in.

Well, Ed, it looked as if the party were all over and there was no stunt forthcoming from that shop after all because methinks I went a step too far. My friend thought I was kidding him and what he told me for my own good I'll not repeat. At any rate I finally got him cooled down again and good natured. After some urging he picked up his story where I interrupted.

"That statement of mine may have been a bit ambiguous," he said, "but when I say that a shaft will break in either one of two places it seems logical to reason that the break is either through a part that is machined or a part that is not, doesn't it?"

I nodded, but said nothing.

"Now if you have an old envelope or something in your pocket, that I can make a sketch on, I'll try to show you what I'm driving at."

I looked through my pockets and forked out the back of an old letter for him to draw on. You'll find the drawings just as he made them enclosed.

"First let us sketch an ordinary shaft with, say, four offsets thusly. Now it doesn't make one particle of difference the number of offsets or their arrangement, but if we assume that the break is in the cheek as shown at (A) there should be absolutely no trouble in welding it, but if the break were located at (B) a different proposition presents itself. It won't take a minute to let you see why but we'll have to sort of generalize to do it. First, I'll say that all welds made by the oxy-acetylene or electric arc process are in reality cast fusions unless they are subjected to some special treatment. What I mean by this is that no matter what kind of metal we're working on, if a weld is made, the metal in the weld and immediately adjacent to it will have all the characteristics of being cast. In other words if two pieces of steel plate are welded together, and the weld finished off flush, it will never be quite as strong as the original plate. It may approach it very closely but the fact remains that it can not equal it. The same thing will apply to crank shafts. To start with they are usually drop forged so that the grain is very close. At the break (A) there is plenty of room to build up the weld but on any machined surface such as at (B) where it must be held to a certain size, then the weld will not be as strong as the original. And of course if the original wasn't strong enough then welding at that point won't help matters much.

"Now, I've figured this all out," he continued. "I've watched the other fellows and checked them up pretty carefully and finally doped out a method which has given me wonderful success. Here it is, I'm going to hand it right over to you. Realizing that I couldn't make my weld on a machined surface I had to devise means of making my weld some other place. That was the key that unlocked the door. Simply move the weld away from the machined surface. Perfectly simple, here, let me have that paper back again and I'll make another picture for you. I won't draw the whole shaft this time, just the off set where the break (B) is supposed to be. The part (B) represents a piece of new shaft turned in a lathe to exactly duplicate the broken part shown at (B) only this new shaft is left long enough to project through the cheeks on each side. Now, having first jotted down all the measurements necessary, we use our cutting torch to remove the broken stubs of (B) close up to the cheeks and then cut a hole in each cheek to allow the ends of the new shaft (B) to fit in. These holes should be large enough to allow a little play for (B) as it may be necessary to move the new shaft around a little before the exact alignment is found. The shaft should then be tacked in from each end and tried out between centers on a lathe. If satisfactory, the welds are made from each end (C) and (D) as you can plainly see.

"There you have the whole thing in a nut shell and if your friend is half as good a welder as you've lead me to believe, it ought to appeal very strongly to him. When it comes to the average welder, half of them don't know what a real fusion means, especially on steel, so when it comes to crank shafts where there is generally a trace of nickel, they are lost. By the way did I tell you that I always use a nickel steel filler-rod on all my crank shafts?

"I don't know as there is very much more to tell," he said in concluding, "except to mention again that alignment is the big thing in shaft work and if too badly sprung it's a real job to restore them to normal. It can be done though by heating up and drawing out the short cheeks under a hammer and closing up the long, but in work of this kind I find that it's just like everything else, experience is the best teacher."

Well, Ed, I was awfully glad to catch up with a chap like that and I told him so but he cut me short.

"There is one favor I'm going to ask you," he said, "what do you say?"

"It's granted," I answered, "providing it doesn't involve money."

"It don't, just let me know what your friend thinks of my stunt and how he gets along with it, that's all."

So now you see it's up to you, Ed. I'll stop at Spokane but not long enough to get mail from you. Better write me at Butte. I don't know where I'll stop there so just make it care of general delivery.

Yours,

Shep.

PROGRESS IN STEEL WELDING

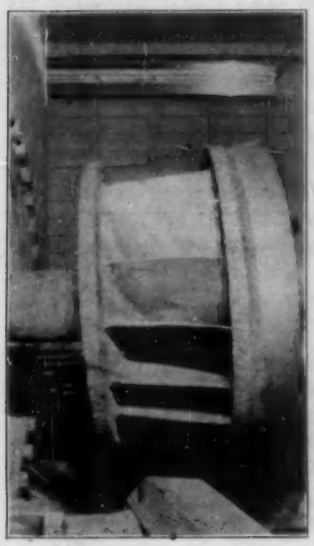
In the early stages of welding steel and even up to recently, the practice consisted too often in filling a steel weld with whatever rod was ready at hand. This often resulted in poor or weak welds and in a prejudice against the art in general.

Much research has been conducted recently both on the correct mixture of gases and the proper distribution to attain controllable temperatures as well as on the kind and composition of the rod which is to supply the welding metal. Attention has also been paid to the use of proper fluxes as well as to the needs in obtaining a high-grade weld, of being certain that the base metal and the welding rod are fused at the proper temperature to insure a thorough mingling of the metals. It has been conclusively demonstrated that to obtain a weld as good or better than the original metal it is necessary to use a rod of a composition which will produce a joint better than the original or base metal. To attain this, rods of various compositions, including nickel steel, manganese steel and other alloys, have been developed. Their judicious use in the hands of experts is producing results hitherto unexpected.

It may safely be said that the art of welding has developed to a stage where, by controlling the temperatures, the materials and the fluxes, furnace conditions originally existing in the actual manufacture of the metal are imitated as nearly as possible at the welding point, to the decided improvement of the welded portions. Reinforced by modern practice and apparatus in heat treatment as well as by new magnetic devices, already in use or in prospect, for testing the reliability of welds, it is probable that still more advances may be looked for, not only in steel, but in brass, copper and other nonferrous metals.—Iron Age.

REPAIRING BRONZE WATERWHEEL BY ELECTRIC ARC WELDING

Few people realize the wide range of possibilities that are available with the electric arc process of welding. A graphic instance of saving time and money by making use of the process is furnished in the repairs of a heavy bronze casting for the Pacific Power & Light Co., of Yakima, Wash., by Drolet & Laurent, electric welders. The repairs not only saved the purchase of a new unit, but also several months required to obtain one from the factory. This is a 36 in. Victor Turbine built by the Platt Iron Works Co. It is directly connected to a 3000 KW alternator. The runner on the unit is of bronze and several months ago serious fitting took place so that the discharge ends of the vanes were fitted clear through and the bases of the vanes fitted so that one broke out, fracturing eight of the remaining ones before the machine could be brought to a standstill.



Shaft and Runner After Welding

Some of the Valves Partly Welded

A thorough examination was made and it was found that the clearance on the discharge ends of the runner was 0.22 in., while on the opposite ends it was 0.14 in. Those dimensions were too great. At first it appeared that it would be necessary to junk the runner which would mean approximately $5,000 to purchase a new one.

However, electric arc welding was tried and 178 lbs. of bronze filler rods were used to build up the clearance and broken parts. The clearance rings were then removed and machined true, after which the runner was put in a lathe and the clearance machined to proper size.

The vanes were finished by means of a portable electric driven grinder. The shaft, 10½ in. in diameter, was also worn, so a distance of 14 in. was built up and machined to size. A test showed that the power of the station was increased 350 KW. by the changes. The average clearances on the exhaust and of the runner was 0.025 in. and in the head end 0.033 in.

Several filler rods were tried and experimented with. The best results were obtained with a bronze rod. This filler rod was tried as a straight electrode with the electrode both negative and postive, but the best results was obtained with a carbon arc. A ¾ graphite was used for the arc; 150 amperes and 60 volts gave the best results.

After welding part of the broken vane and giving the work a thorough test, it was decided to complete the job in this way. Some difficulty was encountered when the arc was broken, as it generally left a cavity or blister. It was found that by holding an extremely short arc before breaking, this difficulty was overcome.

The broken vanes were very difficult to weld, as the space between them on the head end was less than four inches but by using an extremely short graphite, a good weld was obtained. The greater part of the welding on the vanes was vertical welding. A small portion of the weld was done on one vane, then the runner turned to the opposite side and so on until the welding of the vanes was completed. The same system was used on the runner. The object of this was to distribute the heat as much as possible. The job was completed without preheating and no fractures or warpage was experienced throughout the job. All welded parts had to be finished to original size, therefore, no reinforcing or building up was possible. The shaft, 10¼ in. in diameter, was built up, fifty-two pounds of ¼ steel welding rods being used. On the shaft 125 amperes and 60 volts gave best results.

Shaft and Runner After Being Machined to Size

Another View of Shaft and Runner Ready for Service

This job has been in service almost constantly for one year. About one month ago the runners were thoroughly gone over and inspected. It was found to be in first-class condition.

THE INSURANCE MAN AND ACETYLENE

(Continued from page 25)

In the debatable ground that lies between welds that are undoubtedly permissible and proper, and the other class that the insurance companies decline to countenance on account of the serious nature of the responsibility, cases frequently arise where a weld would be considered to be permissible it were properly and carefully made, and not permissible otherwise. In every such case the insurance company should be quite ready to make every due allowance for excellence of any kind in connection with the performance of the work. Superiority in the filling material; the use of apparatus of an approved type; the employment of standard and thoroughly tested methods; the assignment to the work of faithful, intelligent, responsible men, having good judgment and wide experience—all these points are worthy of the most careful consideration in such a case, and I am sure you will find the under these circumstances—so long as the projected work lies in the debatable middle ground, as I have said, and does not come within the province where even these advantages aro believed to be inadequate to insure results of a sufficiently definite and positive kind.

All insurance companies know that broken steamship shafts have been welded satisfactorily for many years past, and we

know of numerous other successful operations, large in magnitude and important in character; and we know, too, that many welded joints that have been tested to destruction have yielded most excellent results; yet we also know that many presumably good welds have failed, and we still feel that it is proper for us to insist upon our original thesis and ask you gentlemen to show us how we can tell, in any given individual case—definitely and without inference or conjecture—just what kind of a job we are dealing with. We want a workable testing method; and until that comes I fear we shall be as obstinate as Shylock, who, when Gratiano asks if no prayer can move him, says "No," and adds

"Till thou canst rail the seal from off my bond,
Thou but offend'st thy lungs to speak so loud."

Can anything be done to remedy this situation? To me, as an insurance man, this is equivalent to asking what means can be devised, to obtain positive and trustworthy evidence as to the soundness and safety of any given individual weld, without destroying the structure of which the weld is a part.

Naturally, the first thing that suggests itself is the ordinary hydrostatic test, such as is applied to boilers and other pressure vessels. If the thing that is welded is of such a shape and nature that a test of this kind is applicable, we can at all events ascertain that the structure containing the weld has a certain minimum strength, though we might not be able to say much about the weld itself unless it were rather long. If the weld were short, the stresses in the adjoining parts of the structure might flow around it sufficiently to prevent rupture under the applied steady load, even though the union at the weld were poor; and in such a case we should only know that the union was good enough to prevent leakage, but we should have to guarantee that fracture would not occur at some later time.

The hammer test is probably the best one that has yet been worked out in practice. Serious defects in a weld can often be found by this method in the hands of a skilled man; and the verdict of such a man, after a careful hammer test, would be received by the insurance company with respect, and considerable weight would be assigned to it. Yet I feel that it is not a sufficiently positive method to justify the acceptance of welds in places where insurance companies do not now consider them to be permissible.

One of the most interesting of the methods that have been proposed for testing a finished welded joint in (say) a boiler plate is the ring-test. To apply this, a sample button of circular shape is cut or punched from the plate, in such a way that the line of the weld runs through the middle of the button. The button is then put into a lathe, a hole is bored through it perpendicularly to the surface of the plate, and the whole thing is turned up in the lathe and finished, so that it has the form of a ring with a rectangular cross-section—each dimension being brought to a standard size, predetermined for this particular thickness of plate. The ring is then stretched (or broken) by forcing a tapered pin through it, and a record is made of the ultimate stretch of the ring before fracture, or of the force that must be applied to the pin to stretch the ring by a given amount. This, when compared with the corresponding result obtained from a similar ring prepared from a button taken from some part of the solid plate, is supposed to give a definite measure of the strength of the weld. If desired, a number of test buttons can be taken at selected points along the line of the weld, and thus practically the entire weld can be tested. As a final operation, the holes from which the buttons were taken are filled up with new metal. This ingenious mode of testing is doubtless capable of giving good results in many cases, and yet it is obviously not ideal—partly because in filling up the holes the joint must be strongly heated after the test, and partly because the cost involved and the time required would usually be prohibitive.

By the use of a "hard" X-ray tube, and a sufficiently powerful induction coil or static electric machine, it is possible to obtain considerable information concerning the soundness of the union at a weld, unless the welded object is too thick. But the apparatus required for making such an examination is quite costly, and at best it could hardly be described as portable. Moreover, an extensive experience would be required before positive results could be guaranteed in this way, and it remains to be proved that a wholly satisfactory verdict could be rendered, in any event.

The electrical resistance of a welded plate, between two points lying on opposite sides of the weld and at a standard distance apart, has naturally suggested itself as a possible quantity to be measured for weld-testing purposes; but this idea would apparently be hard to carry out in practice, and it has not proved practicable, for reasons that will occur to anybody who has made electrical measurements. Exploration of the plate by means of a magnectic circuit might be a more promising scheme, but this has also been tried and found wanting.

May I not now indulge in a few words of prophecy? I am inclined to believe that this problem of proving the condition of a weld is going to be solved, somehow or other; and when it is solved, the welder's art, as applied to the exceedingly important jobs, will take on a new phase. When work of that kind becomes acceptable to the insurance companies it will be done, I think, by large concerns that have a great deal at stake. They will be able to afford the apparatus that may be required and the highly skilled men that will be needed, and they will have special inducements to exercise every possible caution, because the failure of a singular important job might easily mean an immense loss to them in the way of prestige, and a correspondingly heavy loss in future business along this same specialized line.

Finally, I believe that when the kind of work to which I refer is done with the sanction of the insurance companies, it will be done under some sort of a regulative system, almost amounting to licensing; and that the concerns engaged in it will, after due investigation, receive formal expressions of approval resembling permits in their nature, from some authoritative central organization (analogous to the Underwriters' Laboratories), which will pass upon the merits of all applicants and issue certificates of competency to such of them as are found to be duly qualified and duly provided with the necessary apparatus.

Discussion

President H. S. Smith: Gentlemen: I think you will agree with me that is one of the most instructive papers which has ever been read before this Association. The Doctor has been eminently fair in his views. He has said nothing which we, in the acetylene welding industry, could object to.

In the latter part of his paper he dealt with a subject which is vital, and which is in the minds of all in the welding industry, and that is to find some non-destructive method of testing welds. Unfortunately, none of the tests mentioned by the Doctor are commercial. The ring test is generally known. It was devised by the superintendent of welding in the Norfolk Navy Yard, in Virginia. It has been extremely valuable in research work; but it is evident that such a test as cutting rings out every foot or so in your material would be altogether impractical in a commercial way.

There are many points raised by the Doctor in this paper which I believe some of us would criticize if we had the time. For instance, I caught the remark that acetylene might be safe up to 25 pounds pressure. Well, now, in the industry we have endeavored to keep the standard down to 15 pounds. It is not advisable that the general public should get the idea that they can use acetylene at one ounce over 15 pounds: otherwise you lose your margin of safety with them. Men who have investigated the physical characteristics of acety-

WELDING AND CUTTING APPARATUS

MANY a weld takes all the skill in a man's fingers and all the brains in his head. When he is welding a broken aluminum crank case, for instance—what he wants to concentrate on is the heat-diffusion, alignment, temperature of his metal, the oxide, and so on—*the weld itself!*

He wants to *forget the torch*, as a sculptor forgets his chisel!

Before the REGO was perfected, this was impossible. Simply because, very often, the torch required nearly as much attention as the weld itself—to the detriment of the welding art.

Now you can forget the torch when you weld with a REGO.

The explanation: the REGO flame is made by oxygen and acetylene, mixed in the tip, under *low, balanced pressure.*

The REGO flame is neutral, smooth, steady—it will not flash back. Plunge the REGO tip into molten metal, press it tight against fire-brick—still it will not flash. The one torch for close quarters! It will not oxidize, carbonize, or blow the metal.

When you weld with a REGO, you can put your whole thought and skill on the weld itself—you can forget the torch.

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REGO "LITTLE SIX" OUTFIT FOR $57.50

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REGO "Little Six" fills the demand for a small, complete, quality outfit for the garage or repair shop.

THIS is not a departure from the regular REGO line.

The "LITTLE SIX" OUTFIT is a special assortment of STANDARD REGO HIGH QUALITY EQUIPMENT.

Rego "Little Six" Outfit

1 REGO MT torch
3 one piece copper welding tips, Nos. 1, 3 and 5.
1 Cutting tip and tip nut.
1 Special lead welding and radiator tip.
1 Decarbonizing torch (separate and complete).
1 Single gauge oxygen regulator.
1 Single gauge acetylene regulator.
10 Ft. corrugated oxygen hose.
10 Ft. corrugated acetylene hose.
2 Wrenches.
1 Spark lighter.
1 Pair spectacles.
1 Instruction book (Dunham's Automobile Welding).
1 Carrying case.

The "LITTLE SIX" outfit is so called because the man who owns one can perform the six most important types of repair jobs, namely:

1. Welding up to 1 in. thickness.
2. Cutting up to 1 in. thickness.
3. Brazing.
4. Battery repair.
5. Radiator repair.
6. Decarbonizing.

This complete REGO QUALITY outfit with an instruction book that tells you how, all packed in a handy carrying case, is the little outfit you have been waiting for.

Order one now direct or send us the name of your jobber

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lene have differed. Some think we should put it at 15 pounds, and others think we should fix it at considerably over.

Dr. Risteen: About the matter of the 25 pounds gauge pressure as a limit; the reason I put that limit there is, we have in our home office gone on the 25-pound theory, and I am sorry we cannot tell where we got it, but it is a fixed idea with us and it seems to me we must have got it in some good place; furthermore, it seems to me we never have an explosion when there is less than 27 pounds pressure. I think there is no explosion produced under 27 pounds by gauge experiment.

Secretary A. C. Morrison: So far as I know the Doctor is perfectly correct as to the point at which detonation can take place in acetylene. The industry has been taught by severe lessons that it must be conservative in all things. As you say, 27 is the limit. You take the safe side and you say 25. We have gone farther, as we find the human element comes in, and people generally want to go to the limit which is allowed to them. For that reason 15 pounds per square inch has been openly published as the highest safe pressure. That is the limit for the non-scientific, that is the highest point to which they must go. If we tell them they can go to 25 pounds, then they will go beyond that amount. I want to say to the Doctor and others that this Association has been conservative and has not tried to press this limit.

There is debatable ground in all these questions, and we want all of those in the business to press into that debatable ground with all the energy which a desire for profit can put behind them. Because there is a debatable ground is the reason why we should act as an Association, for the consensus of opinion of wise business men is better in the long run than the opinion of any one individual.

As Secretary of the Association, the questions on debatable ground come to my notice as often as anything in the business, and they are brought to the notice of our president and board of directors, who are conservative members, and I have always felt it was safe to go slowly in those matters. I am sure we have all been greatly benefited by the paper you have read, and we have had the high compliment from you, Doctor, of a judicial review of our industry. The paper which has been read is judicial. It balances the pro and con of these questions, and it shows what we must do to keep the esteem of the insurance people.

The next thing is, that we, who are daily familiar with these subjects, who live close to acetylene, know all the hazards which are incident to our business. Certainly we do not weld a boiler when that boiler is beneath one hundred people, unless in the welding of that boiler we know we are doing a safe business. Often we are obliged in our work to take what seem to be risks, to carry a strain, and the strain is such that we must carry it over safely or be absolutely responsible for the consequence.

If we continue to realize that we are dealing with life and property in our business, and that our products might create a hazard, we must consider what our duty is. As time goes on we will not only win the confidence of the public, but we will open up new fields of development in the industry and will reap a rich harvest.

The corporate name of the Seamweld Equipment Co., 81 Winnebago Street, Milwaukee, Wis., has been changed to the Fred Pabst Company, and proposed to enlarge its line of activities in the metal working field. The controller of the concern is Frederick Pabst, president of the Pabst Corporation, occuping part of the former brewery group.

The Wilson Welder & Metals Co., Inc., 132 King Street, New York, manufacturers of arc welding machines and certified welding metals, announces the appointment of Mr. R. L. White as district manager in charge of Detroit office, 809 Kresge Building, Detroit.

HYDE WELDING PROCESS

By D. Richardson

Some few years ago a method of uniting iron and steel which partakes of the nature of both welding and brazing was invented by Mr. A. C. Hyde, of the Hyde Welding Co., Wolverhampton. This method, which is now in commercial use, consists essentially of uniting the surfaces by means of molten copper, but it differs from brazing in the fact that the copper impregnates the mass of metal to be joined and unites them in such a way that they cannot again be separated by heat.

The process is usually carried out by placing together the pieces to be joined with a small piece of copper wire or strip adjacent to but not between the joint, and then raising the whole to the melting-point of copper while surrounded by an atmosphere of hydrogen. With articles of ordinary size they are simply put into a muffle furnace through which hydrogen is passed, the gas being ignited and burnt as a small flame where it leaves the furnace. The surfaces need not be cleaned nor is any kind of flux used. The effect of the hydrogen is to reduce any rust or scale to the form of spongy metallic iron, which presents an excellent surface for the copper to penetrate. If a small piece of copper is placed on an iron plate and heated in an atmosphere of hydrogen to the melting point of the copper it spreads out at once over the iron in a film.

The fluidity of the copper melted under such conditions is extremely high and penetrates the minutest crevices. This somewhat remarkable result cannot be due entirely to the deoxidizing effect of the hydrogen because equal results are not obtained when the atmosphere consists of other deoxidizing gases. The hydrogen appears to act as a flux, cleansing the surfaces and causing the copper to wet it and to flow freely over it.

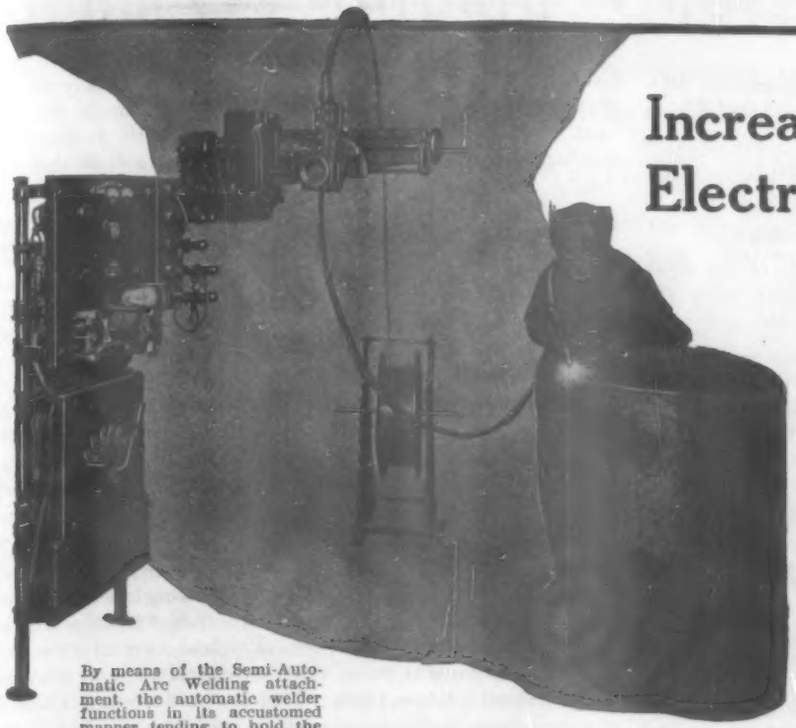
In connection with the process an important phenomenon is observed. The copper not only "solders" the surfaces together in an effective manner as shown by microphotographs, but if the joint is maintained at a high temperature for any length of time after the copper has melted, the latter metal permeate the steel faces for a considerable depth, forming an alloy of steel and copper with individual characteristics.

It is not necessary to use pure copper to obtain the effect described as alloys of copper and tin give the same result. Another remarkable property obtained with the process is that welded articles exposed to damp and corrosive fumes which do not attack copper readily, apparently go rusty in time although far less rapidly than the usual electro-coppered ones. If the apparently rusty surface is rubbed and polished, the copper surface will come out again bright and new, it has neither peeled off or otherwise disappeared.

The practical utility of the process has been demonstrated in many ways. For example, in the manufacture of the cage or body of high-speed centrifugal governors for small steam turbines, and for the attachment of distance pieces to the roots of turbine blades. The Hyde process is in the application to the cardan shaft of the Lanchester motor car. The hollow tube forming the body of the shaft is joined to the splined ends and the joint made by the Hyde process.

The forms of apparatus for effecting the process economically are varied, and depend largely upon the articles to be treated. It is claimed that the quickest and most practicable way of bringing the joint to the required temperature is by the resistance method.

The parts to be welded are quickly gripped in the jaws of a standard butt welding machine, the capacity of which varies according to the sizes of the metal dealt with, the only additional fitting required being the cowl or cover into which the hydrogen is sprayed; this cowl is provided with a mica



By means of the Semi-Automatic Arc Welding attachment, the automatic welder functions in its accustomed manner tending to hold the arc length constant, and the operator merely directs the arc as required by the particular job.

Increase Your Use of Electric Arc Welding

Advantages

Saves time ordinarily lost in changing electrodes.

Saves 10% to 25% in electrode material ordinarily thrown away as waste ends.

Operators learn to use it quickly, as they do not require the muscular training for hand welding.

Continuous operation results in few interruptions in the welding, eliminating a source of defective welds.

This new G-E device can be attached to any G-E Automatic Arc Welding head in such a manner that the electrode wire passes from the feed rolls into the flexible tubing and thence to the arc through a guide nozzle in the welding tool.

Automatic electrode feed—hand work

The G-E Semi-Automatic Arc Welding Lead is a device to be attached to the G-E Standard Automatic Arc Welder which obtains the continuous welding features of the automatic welder, and permits the operator to direct the arc as required by the conditions of the work.

This new device consists of a welding tool to be held by the operator, which acts as a guide for the electrode wire. In the handle of the welding tool there is provided a switch for operating the control on the panel of the Automatic Welder. Attached to the welding tool is a 10-ft. length of flexible steel tubing (called the flexible wire guide) with an adapter at the other end for attaching it to the automatic welding lead.

By means of this attachment the operator can work on products where the seam to be welded is of very irregular contour, or on large work where the clamping and travel mechanism for full automatic welding would be complicated and costly.

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inspection window so that the current can be switched off immediately sufficient temperature to meet the copper has been reached. The object of the cowl is to ensure the least possible waste of hydrogen.

Several applications of this system in conjunction with standard 6 K. W. butt welding machines have been carried out of which a few are as follows:

(1) The welding of steel flanges on to steel tubes.

(2) The welding of 0.6 carbon steel to mild steel bar.

(3) The welding of the covers of steel windows.

This is the only process whereby a thoroughly strong joint can be made without any cleaning off whatever being required. The total cost including power, copper, and time costing approximately 1 cent per cover.

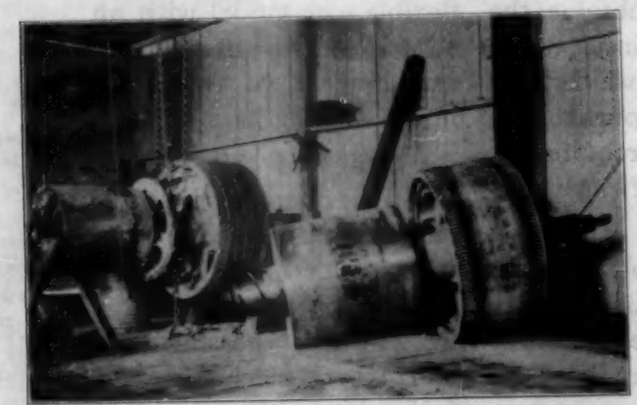
In each case the gas chamber is provided with an inspection hole covered with mica so that immediately the operator sees the copper run he can turn off the current and take out the work. It is an advantage to leave the current on for a short time as this tends to allow the copper to penetrate the surface to a greater depth, but for ordinary work this is not required.

The jigs employed are inexpensive and simple and easily adaptable to standard machines.

NEW MOTORS FOR OLD

Reclamation of burned out or worn induction type motors by means of the welding torch promises to open up an entirely new field of repair for the oxy-acetylene operator, if results reported by J. Otis Crawford, of the Southwest Oxwelding Company, El Paso, Texas, can be accepted as generally applicable to repairs of the kind.

It is claimed that by proper use of welding the repairs to motors can be made permanent and that motors of earlier types can be made equal in efficiency and endurance to the later types of motors now on the market. The particular value of the application of welding in this field would appear



A Permanent and Serviceable Motor Reclaimed at Small Expense

to lie in the fact that very many thousands of old-type induction motors are still in service in the various branches of industry, and in the fact that until now the repairs to such equipment, even when rebuilt, have been regarded as temporary, or only as the restoration of a mechanism that was never quite as dependable as could be desired.

The rotor bars in these old motors are heavy conductors embedded in laminated cores and short circuited on the ends by means of brass, bronze or copper rings in such manner that they form circuits for the current that is induced in the rotor winding. The bars, or conductors, are usually attached to the resisting rings with rivets, screws, bolts or solder. It is obvious that such connections must work loose under constant vibration and as a result of expansion and contraction due to alternate heating and cooling of the parts, thereby reducing the positiveness of the contacts. This adverse condition is aggravated by the collection of particles of dust that sift into the minute crevices, accumulating eventually in sufficient amount to seriously impede the conduction of the current. When the contact areas are sufficiently reduced the conduction zones over heat and rapidly form a scale that will finally destroy the contact altogether. Before this stage is reached, however, the motor will give trouble in starting, will overheat, and will drag; that is, it will run at retarded speed.

This type of motor will function satisfactorily when comparatively new and under ordinary working conditions; but trouble is almost sure to develop after it has been in use a considerable time or when it is subjected to severe service. The usual way of repairing a burnt out or dragging motor is to remove the bars and rings of the rotor and replace them with new construction of the same kind. This virtually renews the motor, but it does not overcome the original fault, which was not so much one of design as it was an error in fabrication, as will presently appear.

A quicker and a very much more satisfactory repair, according to reports received from El Paso, Texas, where Mr. Crawford has successfully reclaimed more than $50,000 worth of old motors for the Southwestern Portland Cement Company in the past 18 months, is to make permanent contacts with the oxy-acetylene welding torch. This can be done, it is claimed, at approximately the same cost as would be entailed in the old way of reconditioning. The advantages of the oxy-acetylene welding over the old method is in the shorter time required and in the permanence and serviceability of the motor.

Motors of 5, 10, 20, 50, 90 and 150 horsepower have been reclaimed at this plant in the following manner: The rotors are removed from the stators and are placed in a lathe so the bar ends can be beveled to an angle of 45 degrees, starting from the ring surface. The metal removed is then replaced by a ring of the best Tobin bronze welding rod, properly fluxed and welded with the oxy-acetylene torch, the bars being bonded to the rings, and the weld running back between the bars a half or three-quarters of an inch (according to the size of the bars, the rings and the rotors as a whole) to insure sufficient conduction area at the joints. To facilitate welding, the rotor should be placed so it can be revolved on "horses" or trestles, the operator being stationed at one side, where he can weld and turn the rotor as his work progresses. Owing to the character of the metals to be bonded it is necessary to use a "hot flame," that is a large size welding tip. When the welding is completed and the work has had time to cool, the rotor is again placed in the lathe and finished.

"If the work is carefully and properly performed," states Mr. Crawford, "no trouble should be encountered and the operation of the rotor is greatly improved."

The first motor reclaimed by Mr. Crawford for the Southwestern Portland Cement Company was an experiment so far as the latter company was concerned. For Mr. Crawford it was a test to show what he could do. The motor was one of 90 horsepower. After being restored to service it ran continuously for six weeks without stopping. Examination then indicated no visible wear or detrioration. That was more than a year ago. Since then between thirty and forty motors have been reconditioned by the welding process for this company, and it is said that there has not been a single failure in the lot.

It is predicted that the welding torch will save thousands of such motors in mines and industrial plants that otherwise would sooner or later have to be junked, or reconditioned at such intervals as to be of no value as a modern power installation.

Managers' Should Understand Welding

Study of the Conditions Necessary to Secure the Best Results—Checking Welders' Ability—Testing Welds

By G. O. Carter*

THE extent to which welding and cutting are employed in the major industries is not generally known. For example, there are 24 distinct uses of oxygen and acetylene, separately and as oxy-acetylene, in a steel mill. In some mills there are as many as 50 points where oxygen cylinders are supplied from the storehouse. Many other industries utilize welding and cutting in almost as many ways, and in many instances a single storehouse supplies a dozen or more shops of an establishment. The problems of distribution of the gases and the efficiency of application are, therefore, numerous.

Some managers may conclude, after reading this article, that welding and cutting are being fully utilized in their plants and that they are getting the best obtainable efficiency out of applications of these processes. Judging, however, from discussions of the subject with many executives, managers are just beginning to study welding and cutting. The tendency is definite, nevertheless, and it is attributable to the strides that have been made recently toward scientific standards in the matters of equipment, supplies, operative procedure and testing.

Study of established application ought to interest almost every manager, and further use of the processes should result in large savings by replacing more expensive methods of production and by obviating the necessity for purchasing new equipment when breakdowns occur, to say nothing of reducing operating delays that are common in connection with mechanical replacements.

The whole history of welding is that its use so abundantly compensates the user that time spent in studying its applications is always paid back many times over. We must grant, however, that in the past there have been conditions which might justify managers in hesitating to use welding on some kinds of repair work, and the same considerations have warranted some doubt on their part concerning the advisability of some welding applications, such as the welding of pipe lines and pressure vessels. Fortunately, research and engineering have now surrounded welding with such practical safeguards in respect to correct practices and adequate tests that dependable results can now be definitely counted on; and the progress that has been made amply justifies conservative managers, however, skeptical heretofore, in making a fresh investigation of modern welding as an operation capable of improvement and development along standard lines of practice.

It is true that research and development have trailed behind the rapid growth in the use of welding and that the welder too often has been obliged to be a law unto himself—the judge of how his work ought to be done and of its final fitness. In the majority of establishments welding is the one industrial operation that the superintendent and master mechanic have been inclined to leave to the individual workman, or at the best to a foreman. Still, welding is very well managed in some plants and shops and it is there, rather than the less carefully managed ones, that show what welding can accomplish where correct practices are followed and when the managerial heads take advantage of late developments in welding the same as they do of advanced practices in other operations in their plants.

The day of managerial study of an attention to welding has definitely arrived, although tardily, as compared with cutting. Oxy-acetylene cutting differs from welding because the cutting jet is the equivalent of a machine tool; it will cut iron or steel where it is directed. The cutting process is one which saves a great deal of irksome manual work in cutting out rivets, severing plates, bars, shafts, etc., and, outside of its economy, is very popular with mechanics. The cutting process has quite naturally taken its place in production work in foundries, boiler shops, structural shops and similar places, and has therefore received considerable managerial attention, but even with this process altogether too much has been left to the operator.

Checking the Ability of Welders

Welders can and should be checked regarding their personal ability. Very simple tests soon indicate whether an operator of the welding torch is capable of making satisfactory welds. If he is working on steel plates, pipe or sheets, sample welds in the form of test coupons can be pulled in a physical testing machine and positive results noted. Average operators should produce welds stronger than 45,000 pounds per square inch and very good operators better than 55,000 pounds per square inch, using Norway iron filling wire and joining sections of average boiler plate. What engineer would not be impressed by such results as compared with the strength of riveted construction?

Should a pulling machine not be available, a welded coupon may be tested by bending in a vise. The weld should be level with the face of the vise and the test piece should be bent toward the side from which welded. A good weld will bend at least 30 degrees in heavy strips, or to 90 degrees in sheet steel welds. This test is easy to make and has been used for years in checking welding ability.

Employers should not be disappointed if their supposedly best operators sometimes fail to make good test bars. A little study will reveal the causes of failure and point the way to avoid or correct them; and this only emphasizes the necessity for ability tests at reasonable intervals. By pursuing this course, managers can make sure that their welders are capable before assigning them to important work. But dependence on the ability of welders should be supplemented, whenever feasible, by the testing of their completed work.

It is generally admitted that welding is a thoroughly sound practice if properly done, but in some quarters there is an erroneous impression that it is almost impossible to know when welding is properly done. Therefore, although welding is giving better results than any other form for joining iron or steel pieces, it is not used to anything like the extent that it should be used. Getting proper welding is up to plant managers. Managers should make sure that their welders are capable of doing excellent work and see that they do it. Welders should be supplied the means of producing sound welds (one of the prime essentials is high-quality filler rods) and their work should be checked by as severe tests as possible. If these things are done, the high quality of the resulting work will be assured.

Welding Ammonia Receivers

As an interesting illustration, attention is called to one of the many large industries where welding has shown to be essential—making ammonia receivers for refrigeration plants. Riveted seams in ammonia receivers save no end of trouble

(Continued on page 40)

Consulting engineer, Linde Air Products Co.

RAILROAD WELDING STANDARDS*

General Rules for Using Autogenous Welding Processes Including Boiler Repairs and Building Up Worn Parts

By G. M. Calmbach

IN order that greater uniformity and better results may be obtained in preparing work and making welds, the following methods and practices have been selected after considerable study, experiments and personal observation of the welding work in many shops throughout the country. They are considered the best and most practical methods in use today and are recommended as standard practices, to be followed as closely as local conditions will permit. Each foreman and welder who follows these instructions will find his work more reliable and satisfactory.

1.

In welding cast iron, brass, cast steel and forgings, all such work should be fire heated whenever possible to insure a better weld, as well as to save gases. That is to say, all parts that take considerable time to heat with the torch sufficient to commence welding should be preheated so that when the welding flame is applied the part to be welded will respond almost immediately. As the oxy-acteylene torch cost per hour is extremely high it is easy to see that the heating of ordinary heavy parts with the oxy-acetylene flame is a very expensive operation and should be eliminated as far as practicable.

All foremen in charge of such work should use good judgment and take a personal interest in this matter and see that the proper provisions are made and work carried out accordingly. The preheating of cast iron, brass and other heavy castings is not only necessary for the saving of gases and time, but is also necessary in many cases to take proper care of expansion and contraction.

2.

In making a successful weld there are five very essential and important things to consider: (1) the condition of surfaces; (2) the bevel of sheets; (3) the position of sheets; (4) provision for expansion and contraction, and (5) proper filler metal.

The importance of these points cannot be overestimated and the failure to comply with the instructions covering any one of them will result in a questionable or bad weld. The success of a weld depends on the rigid observation of these items.

3.

When sheets and patches are to be applied extreme care should be taken that all defective parts are cut out and also that they are cut so there will be a good foundation for the weld.

4.

All sheets and patches should be cut out on a straight or uniform line, avoiding staybolts wherever possible so that staybolts threads may be cut in unwelded plate.

5.

Never cut out sheets or patches through the old weld where sheets have been welded previously. For side sheets or three-quarter door sheets, extend the new sheets at least one staybolt row higher; for crown sheet, one staybolt row lower; for patches, at least one row of staybolts larger; for the flue sheet, extend the weld to one row of staybolts lower.

6.

Do not cut out sheets or patches and bevel the sheets at the same time. If the sheets are to be beveled with the torch before chipping, this can be done after the parts are cut out; this is necessary to insure a uniform line ,as well as a more perfect fit of the new parts.

7.

Clean surfaces are absolutely necessary for making good welds. If scale, rust, or grease is permitted to remain on the surface to be welded a slag is formed that will make a streaked and seamy weld. All surfaces must be kept free from foreign substances; all welding surfaces must be kept clean and bright.

8.

Experience has proven that the most satisfactory angle of the beveled faces preparatory to making the weld is an angle of 45 degrees with the surface of the sheets. The total angle between bevel faces must be 90 degrees in all cases, even if one sheet has to be beveled more than the other. Improperly beveled sheets prevent the welding flame from penetrating to the bottom of the weld and so prevent the weld from uniformly uniting with the edge of the sheet.

9.

Where horizontal welds are to be made with the electric welder, it has been found good policy to bevel the bottom edge to about 60-degree angle and the top edge to about 30 degrees.

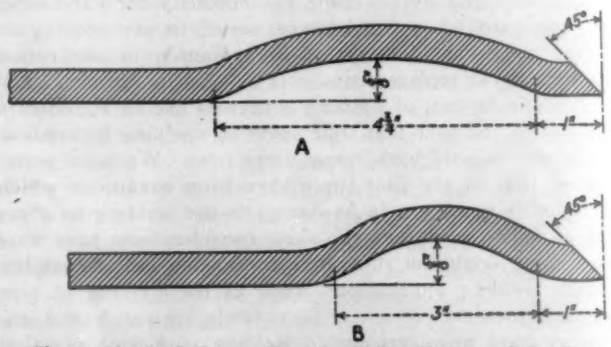


Fig. 1—Standard Corrugations for Boiler Sheets and Patches.

10.

All sheets and patches are to be fitted carefully with an opening of 1/8 inch, no more and no less, between bevel edges. Less than 1/8 inch opening between the sheets will not permit the welding flame to penetrate the weld properly and a greater opening requires too much filler metal to be used, not only increasing the cost of the weld, but making it impossible to keep the surface of the weld opposite the torch smooth. This rough surface permits lamination and seams on the water side of the sheet, weakening the weld and permitting early corrosion of the metal which tends to part the sheets.

11.

All other precautions may be carefully made and yet a faulty weld will be made if due care is not taken to allow for expansion and contraction of the sheets. Where it is not possible to obtain the necessary expansion and contraction through curves of the adjacent sheets, it is then necessary to provide some method to take care of expansion and contraction. In this case all sheets and patches will be cor-

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rugated, as shown in Fig. 1. A strain on a weld, especially where the new sheet is welded to an old sheet, which is generally the case, is particularly harmful as the old sheet will not stretch as much or as uniformly as the new one.

12.

When fitting corrugated sheets or patches, they should be bolted securely in place and when they extend to the mud ring good drift pins should be inserted in the mud ring holes so that the sheet cannot move upward due to the contraction

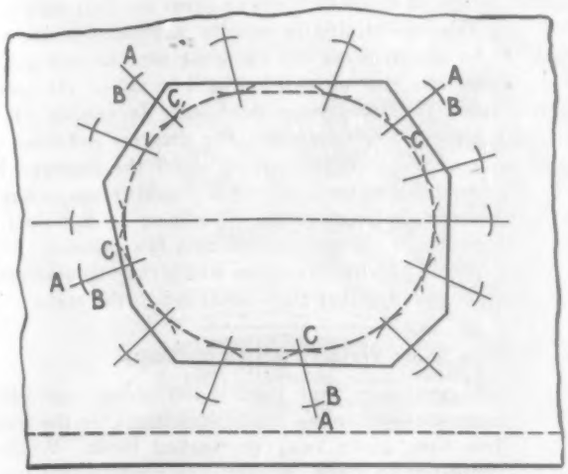

Fig. 2—Method of Laying Out Patches for Welding

as the contraction should be taken from the corrugation. Bolt the sheets at the welding end as usual. That is to say, insert a ⅝-inch bolt through every fifth staybolt hole and screw in a staybolt from the outside between each of the ⅝-inch bolts, thus holding the sheets in line. Then insert small wedges between the welding edge spaced about 14 inches apart to keep the sheet from pinching together during the welding.

13.

Where side sheets are to be welded at the end it is necessary to remove the adjacent row of staybolts to the edge of the flange of the door of the flue sheet before welding is commenced. It is also advisable to remove all staybolts adjacent to welds after the welding is completed.

14.

When welding corrugated sheets or patches with the oxy-acetylene method the following instructions are to be carried

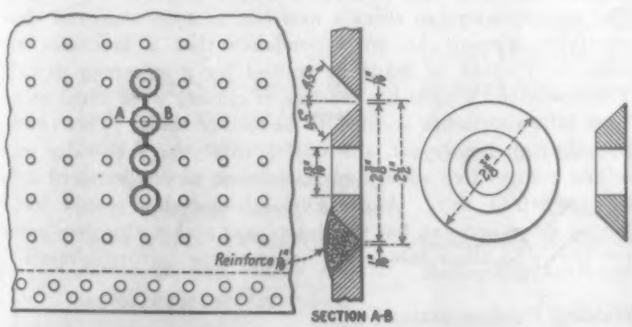

Fig. 3—Method of Welding Cracks Through Staybolt Rows; Gas

out: With every 12 inches of welding completed, the operator will stop and heat a line 1 inch wide through the center of the corrugation to a red heat and continue this until the weld is finished.

15.

No firebox welds should be reinforced more than $\frac{1}{16}$ inch as too great a reinforcement is injurious to a weld due to overheating when in service.

16.

For firedoor patches when collars are to be welded they should be cut out at a point where at least one row of staybolts is in the patch and as nearly round as possible. When the patch is cut out at a point 6 inches or more from the firedoor edge it should be corrugated all around as shown in Fig. 5. It will not be necessary to corrugate if the patch is cut out less than 6 inches from the door hole. When fire-

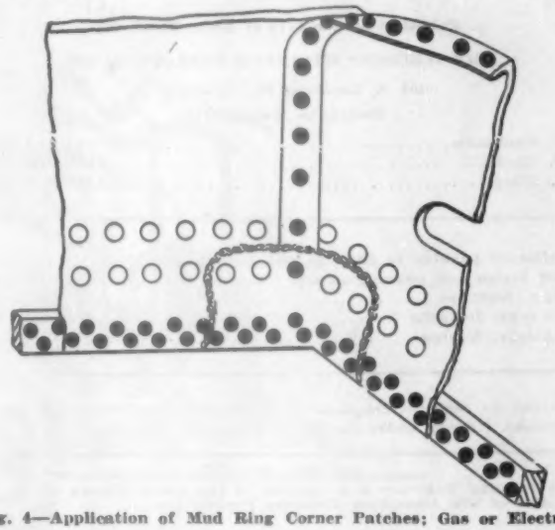

Fig. 4—Application of Mud Ring Corner Patches; Gas or Electric

door patches are extended to the mud ring and 6 inches or more from the firedoor edge the patch will be corrugated all around. Where patches do not extend to 6 inches from the firedoor edge, it will only be necessary to corrugate both sides of the patch from a point about half way from the firedoor down to the mud ring.

17.

The welding of cracks in side sheets, door sheets, firedoors, crown sheets, bottom and top of flue sheets should never be attempted as such attempts have been a source of much trouble and many engine failures. However, it may

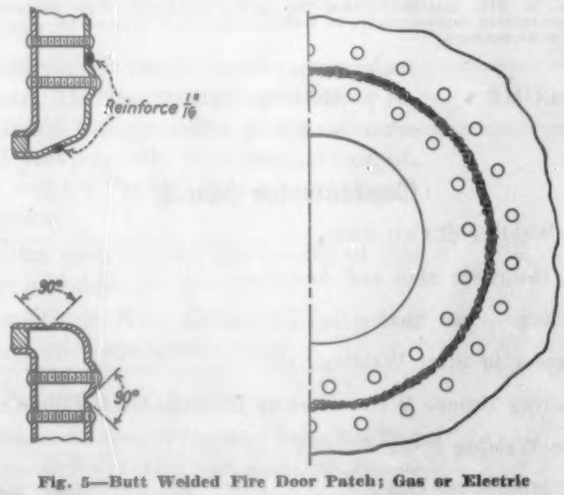

Fig. 5—Butt Welded Fire Door Patch; Gas or Electric

be considered necessary at times to weld certain cracks. This practice should be resorted to only in occasional emergency cases and then such work should be classed as strictly temporary and be corrected at the first opportunity. It is, of course, known that such work as welding cracks in the barrel of a boiler, welding over staybolts and welding staybolts is strictly against the law and will not be allowed at any time.

18.

When it becomes necessary to weld seams that have given

(Continued on page 42)

The Welding Engineer

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Bootlegging Welding Wire

ALTHOUGH there are a number of advertised brands of welding wire on the market, giving the welder his choice of several different makes of filler material of proven quality, there are indications that tons of non-descript wire, such as baling wire and fence wire, are annually sold for welding purposes. "Any old wire" will not make good welds, by either the gas or electric process. Real welding wire and rods are made by carefully controlled processes. The manufacturers are forced to make them uniform for their own protection and this uniformity is equally a protection for the welder. If he simply buys the cheapest wire he can get, it is more than likely that no two lots will be alike. He cannot weld with such junk and have confidence in results. It is the welder himself who can exert the greatest influence toward chasing undesirable filler material off the market. He can do it by refusing to buy it, and he should refuse to buy it because whenever he uses it his reputation as a welder is being endangered for the sake of saving a few pennies. Stick to standard brands of wire, brands in which the manufacturers have enough confidence that they advertise to the trade.

Rivet Failures Show Welders An Opportunity

GARAGE repairmen find that nearly every car which comes in for overhauling needs some work on the frame because rivets have given away or worked loose. Welding can be accomplished so much cheaper than riveting that many car makers would weld instead of riveting provided they were shown how to use welding to the best advantage. A poor weld has no advantage over a rivet when parts are subjected to severe vibration, but a good weld has several distinct advantages, and there are scores of joints in an automobile assembly which might well be made by one of the various welding processes.

Right Around The Corner

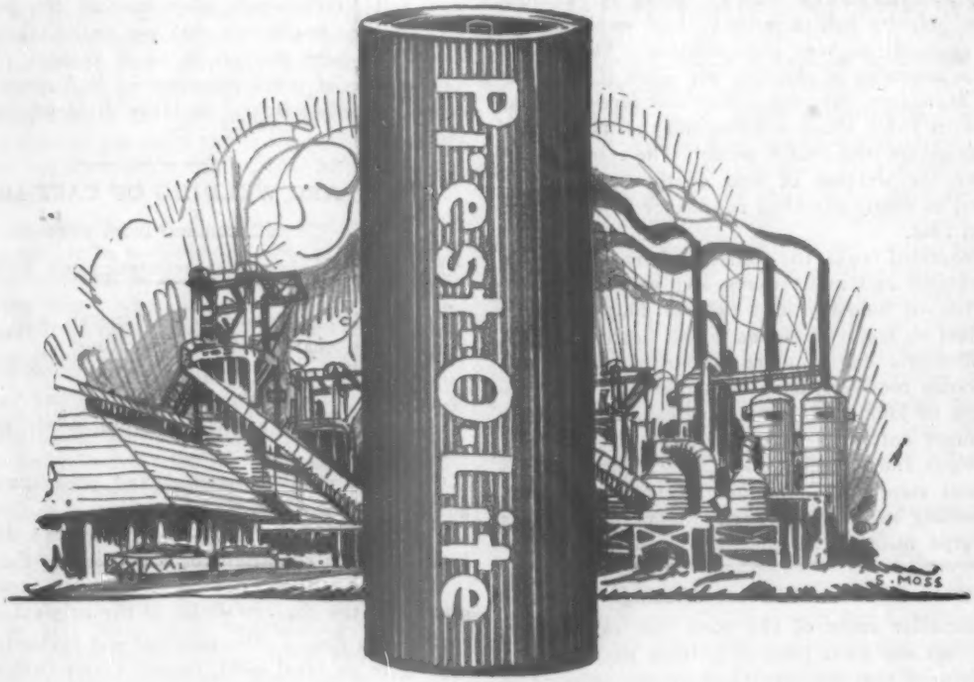
RIGHT around the corner there is a good order waiting for nearly every business, and the salesman who keeps everlastingly at it will eventually turn the right corner and land the order. One good example shows up in the report of a salesman who jumped a high barbed wire fence to come in the back door of a welding shop because the purchasing agent would not let him in the front door. His unshaken faith that the shop needed his apparatus finally got him an audience, and a sale. Another example is found in a supply dealer's story. Here was a golden opportunity that never was cashed. The dealer wanted to stock a new line of apparatus, and after satisfying himself by correspondence that a favorable arrangement could be made he waited for a salesman to call. The salesman thought his chances of closing were small so he kept following what seemed to be better leads. This condition kept up for a year, and during that year the dealer was selling competitive apparatus at the rate of one hundred dollar's worth a day. Aggressive salesmanship would have landed a fine account, but the dealer was playing his own game too busily to allow taking the order to the factory himself.

Welding Firebox Seams

A RECENT editorial in the *Railway Mechanical Engineer* points out the necessity for caution in the application of welding where it may get blamed for some other defect in the locomotive boiler or where a failure will bring the process into general disrepute.

One safe rule to follow is that recommended by the Bureau of Locomotive Inspection: Never weld around the crown sheet or combustion chamber of the firebox sheets where low water can possibly expose the sheets to steam and thus permit the welded portion to become unduly heated.

Read on this page, from issue to issue, a description of the features which have made Prest-O-Lite a national institution



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DISSOLVED ACETYLENE

MANAGERS SHOULD UNDERSTAND WELDING

(Continued from page 35)

before welding was introduced; but in taking up welding, the refrigeration industry had to insist on high quality work, as leakage of ammonia is very objectionable. Throughout this industry the necessity of checking the work of operators is recognized. Managers, superintendents and foremen make it their business to know about welding and the handling of welders and thus assure dependable welds. The result of this application, after the welding of tens of thousands of receivers, has been to firmly establish confidence in welding in the refrigeration field.

Welding of enameled tanks, the welding of rear axle housings for automobiles and auto trucks and many other interesting branches of industry in which welding is now a recognized production factor might be noted; but they would only serve to illustrate one or more properties that, in the welding of ammonia receivers, have been highly developed—the gas tightness of joints that must not leak, the strength of joints that must not yield under high internal pressure, resistance to fatigue and vibration under internal tension. It was but a logical step from ammonia receiver welding to general pipe welding as now practiced—the welding of gas pipe lines, oil pipe lines, water pipe lines and steam pipe lines.

Tests to Determine Correct Welding

Now let us consider some of the tests that can be employed to prove that any given piece of welding work is right. Industry is convinced that wherever hydrostatic pressure in excess of the working pressure can be applied it should be utilized as part of the test. While the pressure is on the work, repeated blows of a suitably weighted hammer should be given to the welded section. If there is a serious defect in the weld, this combined pressure and impact test will show it up. What managers would be in doubt as to the strength and durability of welded pipe lines, storage tanks or pressure vessels that had passed a test of double the proposed working pressures and then hammered?

A feature of one other form of welding will be touched upon, as it offers returns to the managers utilizing it. Repair welding of castings, no matter how large, can be made almost 100 per cent successful provided proper preheating and annealing facilities have been used as an important part of the work. Broken castings can thus be repaired in a fraction of the time that would be required for replacement and at a cost far less than that of replacement or of any other method of repair. There are single establishments having repair welding shops that average one big welding job a day, effecting the saving of tens of thousands of dollars yearly. Such shops should be as well organized and equipped as a machine shop or a foundry and have adequate preheating and annealing facilities.

Engineering Advice Available

Any investigation of the possibilities of the welding and cutting process as time and money savers should include the engineering advice which is available to those who seek it. Many of the manufacturing and supply companies maintain engineering and research departments. These devote their attention exclusively to the problems which come to them from the users' own work, and to the development of the industry through aid rendered to present and potential users of gas welding and cutting. Standards of practice based on a contact with actual work being done in hundreds of plants have been well developed.

A large amount of information from these engineering and research activities as well as specific applications are featured by the trade journals which are devoted to the welding industry and other papers. These journals should be utilized for keeping abreast of current developments.

Because the oxy-acetylene process is a comparatively new tool in the hands of American industry, many users of the process are not fully aware of the tremendous strides that have been made in the direction of those standards of practice, tests, etc., which have marked the progress of other processes or operations that are today taken for granted as being in sound practice in every respect. There is hardly any feature of plant management and operation where time spent in study will pay as large dividends as in this field.—Iron Age.

ARC WELDING OF CAST IRON

(Continued from page 22)

Each of the above characteristics can be obtained as follows:

(1) Good amalgamation of metals can be obtained by proper filler material and preheating.

(2) Chilled metal at the lime of fusion or in th weld can be prevented by proper filler material and by preheating.

(3) Preheating will also accommodate expansion in the casting.

(4) Proper filler material and preheating will eliminate gas pockets and holes.

The proper filler material will result in a deposit which will have the same coefficient of expansion as the casting.

The proper filler material can be obtained which will approximate the characteristics of the original casting.

Although proper filler material and preheating will theoretically give an ideal weld, proper manipulation of the process and a clear understanding of the principles involved are necessary in their practical application.

Electrode Material

In good welding practice it is the usual procedure to use filler material having the same characteristics and which will respond to the same treatment, in the same way, as the material of the part being welded. It is also necessary that the expansion and contraction of the parent and added material be the same, and that an amalgamation of metals be secured. It is a logical procedure, then, to use filler materials of the same composition as that of the casting or part being welded. There is usually an allowance made in the filler material to take care of losses of the constituents which may be diminished by the welding process.

Electrode material for welding cast iron by the arc process, if governed by the above findings, would consist of cast iron with the following characteristics:

High carbon content to compensate for the loss of carbon due to the application of the intense heat of the arc and to promote the formation of good cast iron.

High silicon content to compensate for losses and to promote the formation of graphitic or free carbon cast iron.

Low sulphur content on account of its detrimental effects.

Low manganese content because of the retarding effect it exercises over the formation of free carbon or graphitic cast iron.

Low phosphorus content on account of the formation of very brittle iron where any appreciable amount is used.

Various compositions of cast iron electrodes have been tried in conjunction with preheating. The standard filler rods made for gas welding give very good results when coated with lime wash, and when the casting can be welded and heated to about 1500 deg. Fahr.

Preheating is necessary in connection with arc welding of cast iron if a weld having the ideal characteristics is to be secured. It accomplishes results as follows:

(1) It relieves residual strains and accommodates expansion and contraction in the casting and between the original and added metal.

(2) It eliminates gas pockets and holes, caused by reasons

previously stated, by holding the metal in a plastic or fluid state long enough to enable the gas to escape and oxide or dirt to be released and floated to the surface.

(3) It aids in securing a good amalgamation of metals, particularly when welding graphitic cast iron, by reason of the extension of the period of fluidity which allows the slag to float free, and by reason of shortening the period of time required for the dissolving of the carbon, due to the fact that the preheating has already advanced the process. When castings are preheated the formlation of the line of slag is reduced to a minimum.

(4) It permits cooling the metal of both the casting and welded sections as slowly as possible and thus prevents chilling and the attendant formation of chilled iron. Undisturbed cooling promotes the formation of free carbon which is necessary to the production of soft iron. It has been determined that if the cast iron is solidified quickly and then cooled very slowly the carbon, which is in the combined form at the time of setting, will change to the free form as cooling progresses, thus producing a fine-grained iron of first quality. There is an opportunity in arc welding to duplicate this procedure by preheating the casting to the required temperature before casting or welding the filler material into the original metal, thus delaying the chilling and assisting in cooling the metal slowly. The change from combined to free carbon takes place very rapidly (Fig. 7).

Referring to the first point above, preheating to relieve residual strains and accommodating expansion and contraction will be clearly understood if the following points are kept in mind. When a section of metal is heated or cooled the expansion or contraction which takes place will produce stresses. This may be visualized by comparing the effect to the effect produced by driving a wedge between the sections at the point of heat application. The greatest stress is exerted at a time when the metal is just below the point of fusion, or at the time contraction has taken place. The effect of these stresses in welding practice will be understood by referring to Fig. 8. Assume that item 1 is to be welded at the point marked "W" and that the casting section at the point of welding is 5x1 in. An application of welding heat at the point "W" continues to expand the metal at this point until a point just below the fusion is reached. This expansion causes the free end to move outward in order to accommodate the greater bulk of material at the weld, just as if a wedge were being driven into the metal. After the metal solidifies, this greater bulk begins to recede or contract and continues to do so until a point is reached at which the casting assumes atmospheric temperature. With this contraction there is a corresponding movement of the free end of the casting. If, instead of the casting having the flat section shown in 1, it takes the form of that shown in item 2, where the leg section is similar to three sides of the square; the leg, instead of being free to move, is held more rigidly, causing considerable strain upon the lower side of the section and opposite the weld.

Upon cooling, contraction takes place as in the previous example, causing a severe strain in the lower section. If the casting is solid and the section so heavy that the welding heat does not penetrate all the way through, there is the same expansion and contraction, with their accompanying stresses and strains, which often result in warpage and breakage.

Items 3, 4 and 5 show similar examples, the points "W" representing the places of welding and the points "S" where the greatest strain is exerted. Breakage from expansion and contraction stresses does not always occur at the point of greatest stress application, but at a point where the strength of the section is less than that required to withstand the stress applied at that point. An example of this is shown in item 3, where the weld is made in the cross member between the legs, and the strain being distributed about the apex of the angle formed at the junction of the legs. If the section of the apex is heavy enough to withstand the energy exerted, the breakage, if any, would then take place in the leg sections, and at a point which is less able to withstand the applied stress at that particular point. A close study of each particular casting with reference to its construction is necessary if proper care and precautions are to be taken.

If the casting is of simple construction it is usually only necessary to preheat it at the points of stress application, as outlined in the previous examples. If the castings are complicated in construction, the problem becomes greater as the intracity and complexity of the casting increases, in which case it is usually necessary to preheat the casting all over in order to compensate for the liberation of residual stresses, expansion and contraction. In addition to preheating, it is often necessary to after-heat the casting, following the welding operation, if successful work is to be done. Many welders believe they are getting away with something when they weld a casting without preheating, and, though the casting may not crack at the time of welding, it may possess residual stresses which will send it back to the welding table like the proverbial cat.

The only objections to preheating are time required, probable warpage, cost and the heat to which the operator is exposed while welding. The latter consideration most often carries the situation when it should be secondary to all others, as it is possible to protect him from the heat if proper precautions are taken and suitable equipment used.

The development of arc welding of cast iron will probably depend upon the development and use of methods and applications of preheating, and the development of an electrode for metallic arc welding on cold castings which will deposit a ductile metal having a minimum coefficient of expansion.

Satisfactory results can be obtained by the steel metallic arc method and by the carbon arc method, using either cast iron or steel filler rods, if the work is preheated. When using steel filler with either method we have to contend with an area of high carbon steel which does not machine readily, even when in the annealed state.

Care must be exercised in the manipulation of the pencil with the carbon arc method, as at each spot where the carbon comes into contact with the surface of the casting a hard spot usually results.

In some cases of welding, when steel filler material is used, very good results have been obtained by annealing in addition to preheating. After-heating results in relieving strains caused by welding and in annealing hardened sections of the deposited metal.

One advantage of the preheating method is that the welding operation may proceed as rapidly as it is possible to push it, while welding done by the metallic arc method on cold castings is exasperatingly slow and tedious, since it is only practicable to add the metal a little at a time in order to keep the heat and attendant shrinkage at a minimum.

It is claimed that metallic electrodes of various compositions will produce a soft weld. The truth is that the added material may remain soft, but there will always exist an area of chilled cast iron on the cast iron side of the weld if the materials have been fused. Cutting with a hacksaw through the weld section will reveal the hard area, if one exists.

A few years ago results obtained by electric arc methods in welding cast iron of any sort were questioned. The progress within the past few years has been such, however, that at present very good results are obtained on the better grade castings and passable results are obtained on castings of almost any grade. As more thought is given to the method of procedure in welding of cast iron, and as a better understanding of the conditions under which cast iron can be welded is obtained, the application will become more general and the art will advance more rapidly.

RAILROAD WELDING STANDARDS

(Continued on page 37)

away, such as those between door or flue sheets and side sheets, the rivets should be removed and the outside of the fire side lap should be cut off through the center line of the rivet holes. Do not cut the side sheet and see that it is cleaned thoroughly before welding is commenced. Weld the holes solid and lap weld sheets.

Fitting, Preparing and Welding Fireboxes

For fitting, preparing and welding a firebox without removing the back end, the firebox should be set up on the

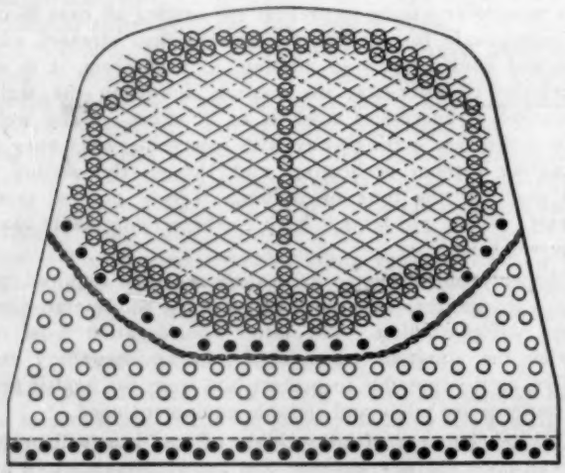

Fig. 6.—Method of Applying New Tube Sheet Section; Gas or Electric

floor with all staybolts and mud ring rivet holes drilled, except the mud ring corner holes, which should be drilled after the sheet is up and welded.

The welding edge should be chipped to a 45-degree angle and chipped on a straight line so as to insure a uniform opening of ⅛ inch between the welding edges.

The lower portion of the sheet from a point about 14 inches from the bottom of the flue and door sheets should not be chipped until the box is in place and the mud ring corners in place.

Bolt the sheet securely in place, being sure that there is a uniform opening of ⅛ inch all around the welding edge.

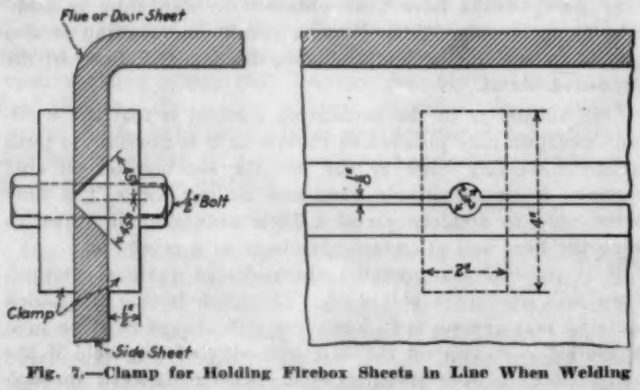

Fig. 7.—Clamp for Holding Firebox Sheets in Line When Welding

Use a ½-inch drill and drill holes spaced about 14 inches apart, using ½-inch machine bolts with clamps made of boiler plate ½ inch by 2 inches by 4 inches. Use one of these pieces on each side of the sheet, being sure that all bolts are drawn tight.

Rivet the top of the flue sheet to a point not less than 12 inches below the center of the crown; start welding at a point about 10 inches below the rivet and weld up to the rivets. Then drop down 10 inches and weld up to the end of the previous weld. Continue this operation until completed, removing clamps when necessary. Weld the entire door sheet.

Examples of Boiler Shop Welding

The method of making corrugations for side and door sheets to allow for expansion is shown at A, Fig. 1. The corrugation for patches is more pronounced and is shown at B in the illustration.

In laying out patches previous to welding it is sometimes difficult to cut them accurately unless some such method as the following is used: After the sheet has been cut out and beveled, the lines A, Fig. 2, are scribed as shown. With the dividers set at about 6 inches arcs B are scribed from the edge of the bevel. When the patch is ready to lay off for size, it is bolted firmly into place, as shown in Fig. 2. The lines A are then scribed back on the patch a short distance. With the dividers set at the same distance used before and with the intersections of lines A and B as centers, arcs C are scribed on the patch. Where these arcs intersect lines A, are points on the edge of the patch. A smooth curve is drawn through these points and the patch cut to the line. It can then be beveled and welded in place in accordance with the standard practice at local shops.

Boiler plates cracked through staybolt holes are a common occurrence and often give much difficulty before repairs can be made. One method of overcoming this difficulty is illustrated in Fig. 3 in which a new circular section of boiler

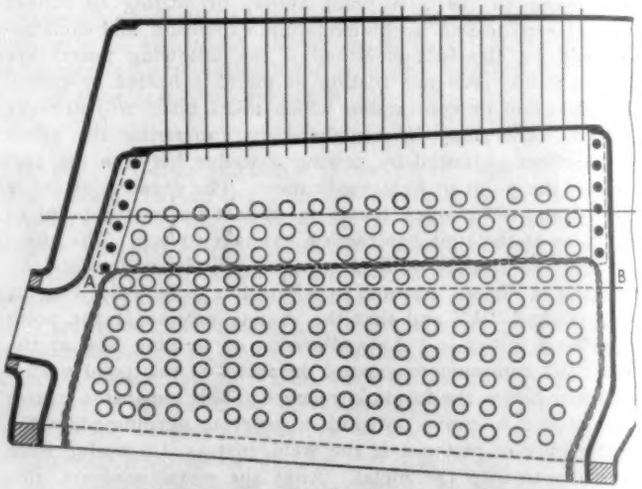

Fig. 8.—Side Sheet Application; Gas or Electric

plate drilled and beveled as shown at the right is applied by welding. It will be noted that the bevels are cut at an angle of 45 degrees and the weld is reinforced by adding ⅛ inch to the thickness of the original plate.

An interesting example of the method of applying mud ring and corner patches is shown in Fig. 4. This operation can be performed either by gas or electric welding, but the caution should be observed of never laying out the patch so that the weld will come lower than between the first and second rows of staybolts above the mud ring.

The method of applying a butt-welded firedoor patch is shown in Fig. 5. The corrugation to allow for expansion is shown and, as in the previous instance, the patch is beveled to an angle of 45 degrees, the well being built up an additional ⅛ inch for reinforcement.

When constant reworking of tubes and flues has damaged the flue sheet bridges, but the lower portion of the sheet is in good condition, the method of repair by welding in a new top section is shown in Fig. 6. This method effects quite a saving in time since the top flue sheet section can be more quickly laid out and formed, and the labor of cutting and reapplying staybolts in the lower section is eliminated. If any difficulty is experienced in bringing the edges of the

new and old plate in alinement previous to welding, a special clamp, as shown in Fig. 7, can be used.

One of the most successful uses of welding in boiler work has been in the application of side sheets and half side sheets. The application of a full side sheet is shown in Fig. 8 with the corrugation for expansion along line A-B.

In making heavy frame welds with gas it is essential that the parts be carefully cleaned and prepared for welding by

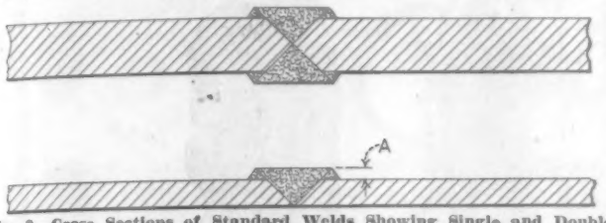

Fig. 9—Cross Sections of Standard Welds Showing Single and Double Reinforcement

cutting the ends to the proper angle and making necessary allowance for contraction in cooling. It is also wise, wherever space permits, to built up the weld a certain proportion larger than the original cross section in order to provide additional strength.

The standard method of cutting, welding and reinforcing bolsters, truck side and engine frames, and all other steel, iron, or cast steel from ¾ inch to 8 inches in thickness is shown in Fig. 9 and the accompanying tables. The amount of

STANDARD REINFORCEMENT FOR ALL HEAVY WELDING

Thickness of Material	Proportional Increase in Thickness
¾ inch—1½ inch	A=25 per cent
1½ inch—2½ inch	A=15 per cent
2½ inch—4 inch	A=10 per cent
4 inch—6 inch	A= 7 per cent
6 inch—8 inch	A= 5 per cent

STANDARD V FOR HEAVY WELDING

Thickness of Material	Angle of V
¾ inch—1½ inch	One side —45 degrees
1 inch—2 inch	One side —55 degrees
1 inch—2 inch	Both sides—45 degrees
2 inch—3 inch	One side —50 degrees
2 inch—3 inch	Both sides—55 degrees
3 inch—4 inch	Both sides—55 degrees
4 inch—5 inch	Both sides—55 degrees
5 inch—6 inch	Both sides—55 degrees
6 inch—8 inch	Both sides—55 degrees

reinforcement provided is a certain proportion of the cross section decreasing in amount as the size of the section increases. It is to be noted from the tables that the angle to which the parts are cut or Ved varies from 45 degrees to 55 degrees; sections over 2 inches thick being Ved and welded on both sides.

Preparation for Frame Welding

As in the usual practice the frame to be welded is lined up, trammed and checked with the opposite side as shown in Fig. 10. The weight of the engine is taken off the frame and jacks placed under the jaws on either side of the weld. Then tram over the break, locating permanent points by which the expansion will be governed. Referring to Fig. 10, the frame should be cut out from both sides to the angle shown, all surfaces being chipped and cleaned preparatory to welding. It is necessary to spread the frame a suitable amount to allow for contraction in cooling, this allowance for contraction varying slightly in amount depending upon the location of the break. Referring to Fig. 10, when breaks occur at points marked A, ¼ inch should be allowed for contraction. At points B ⅛ inch is allowed. Whenever welds are to be made in any part of the jaw the binder should be in place if possible. A ⅜-inch plate should be tacked to the lower side of

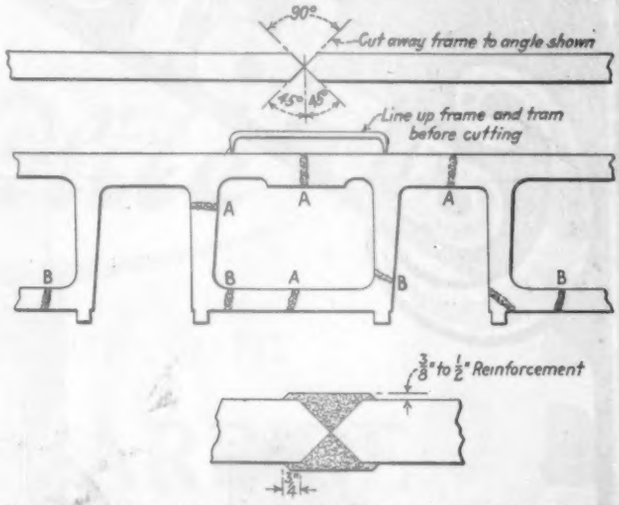

Fig. 10—Location of Common Frame Breaks and Method of Welding With Gas

the frame on which a foundation can be made to start the weld. This plate extends out on both sides of the frame the thickness of the reinforcement and is welded firmly to the frame at all points of contact including the edges. This plate forms a base on which to start the weld.

Two operators should be employed, one on each side of the frame. After the weld reaches the thickness of 2 inches, it should be hammered, this hammering to continue at intervals until the weld is finished. It is important that at no time during the process of the weld any part should be less than red hot. That is to say, the operator should keep the finished part of the weld red hot at all times and when the weld is finished the entire weld should be brought up to an even heat before jacks are removed. This will relieve any

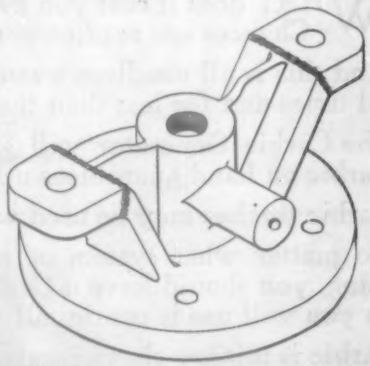

Fig. 11—Air Signal Valve Casting Repaired by Gas Welding

internal stress and decrease the possibility of future breaks.

For the amount of reinforcement to be applied reference should be made to Fig. 9 and the accompanying tables.

Miscellaneous Welding and Building Up Jobs

The possible uses of both gas and electric welding in railroad shops are too numerous to mention and both processes have been greatly extended during the past few years, saving large sums of money annually to the railroads. The important point to be remembered, however, is that either welding process costs money and if the locomotive or car part being repaired or reclaimed is small and has a first cost less than the cost of gas or electricity and labor used, it is obviously poor economy to weld it.

For the air signal valve casting, as shown in Fig. 11, however, the cost of labor and gas used in welding on the broken

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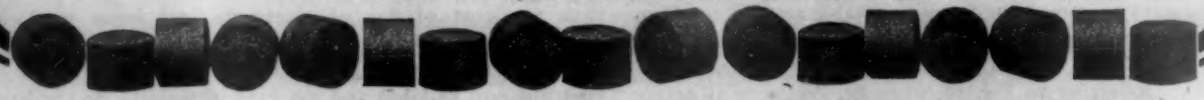

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lugs would be considerably less than the cost of a new casting, and it is therefore good economy to make the repair by welding. The castings after being welded by competent operators will be just as good as new.

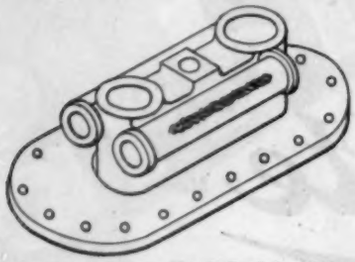

Fig. 12—Air Compressor Steam Head Reclaimed by Gas Welding

An interesting example of what can be accomplished with gas welding is shown in Fig. 12. The steam head of the New York air compressor is located at the bottom and, without proper care in draining during the cold weather, will often become cracked through the wall to the exhaust passage as shown in Fig. 12. This steam head is quite an expensive casting with a more or less intricate system of coring in which it was found necessary to maintain walls of equal thickness. The problem in getting a successful weld on this casting is to provide for contraction and this can be accomplished only by the careful and thorough preheating of the steam head after

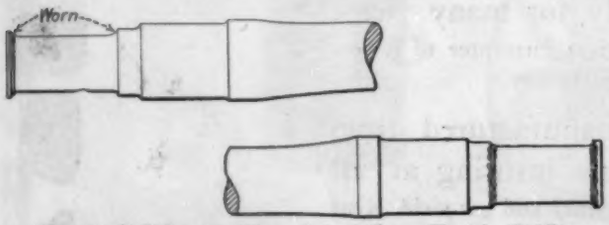

Fig. 13—Building Up Worn Axle Collars; Electric Welding

which the crack can be welded with gas. The entire weld and adjoining walls of the casting should be brought to a uniform temperature and allowed to cool slowly to prevent internal strain and a subsequent crack which will be worse than the first.

Among the possible uses of the welding processes perhaps none is more important than the building up of worn parts, in many cases making them as good as new for further use. The example shown in Fig. 13 is a worn axel collar before and after being built up by electric welding. After the welding has been completed it is necessary to mount the axle in a lathe and remove excess metal deposited on the collar, leaving a smooth fillet of the original dimensions.

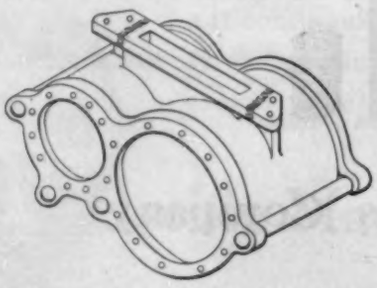

Fig. 14—Air Cylinder Lugs Replaced by Gas Welding

Another example of welding broken lugs is given in Fig. 14 in which both lugs have been broken from an air compressor cylinder, either through a wreck or accidental dropping or mishandling on the floor. The common method of repairing a cylinder with broken lugs is to have new lugs forged of wrought iron or axle steel in the forge shop, fitted to the cylinder which has been properly machined, and secured in place by three or more bolts through the extended sides of the lug and the cylinder. It is obvious that in both cost and

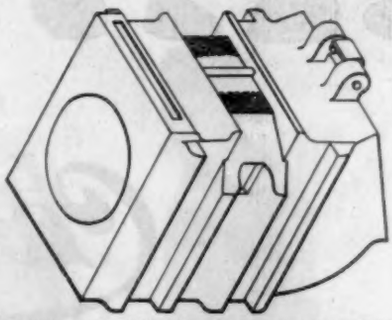

Fig. 15—Building Up Worn Journal Box; Gas Welding Used

length of time required to make a repair, welding is much to be preferred over the mechanical process of applying new lugs.

The method of building up a worn journal box and the ends of an engine brake beam are illustrated in Figs. 15 and 16, respectively. Both of these parts can be built up and made as good as new in a very short time and at a slight cost. In the case of the journal box it is advisable to use gas for building up, but with the brake beam the electric method would be better. In case gas is used to build up the worn brake beam ends, great care must be exercised not to over-

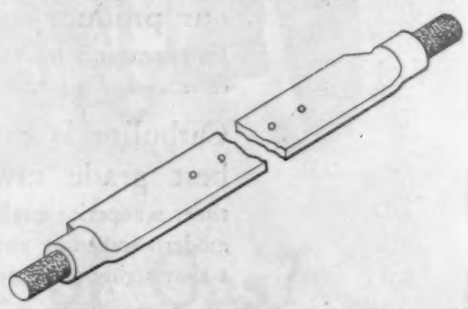

Fig. 16—Building Up Brake Shaft Ends; Electric Welding

heat the ends and the entire beam should be carefully annealed before being machined and put back into service. Otherwise there is a good chance of a train delay due to dropping the brake beam.

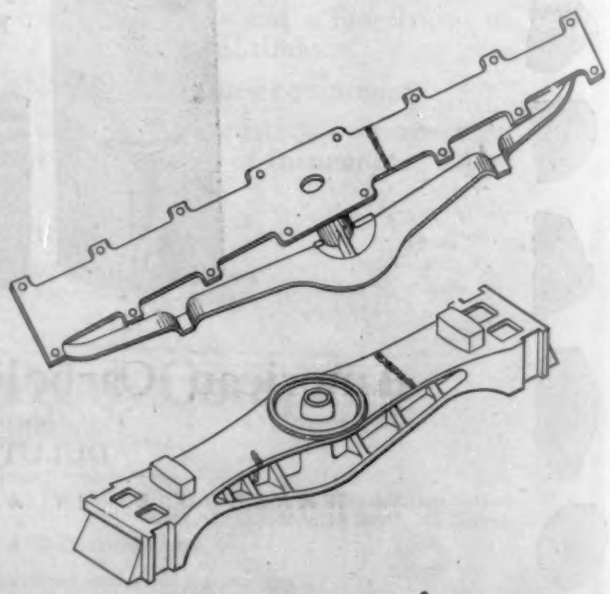

Fig. 17—Steel Car Bolster Effectively Repaired by Gas Welding

The possibilities of welding are also illustrated in Fig. 17 showing heavy steel car bolsters which have become cracked

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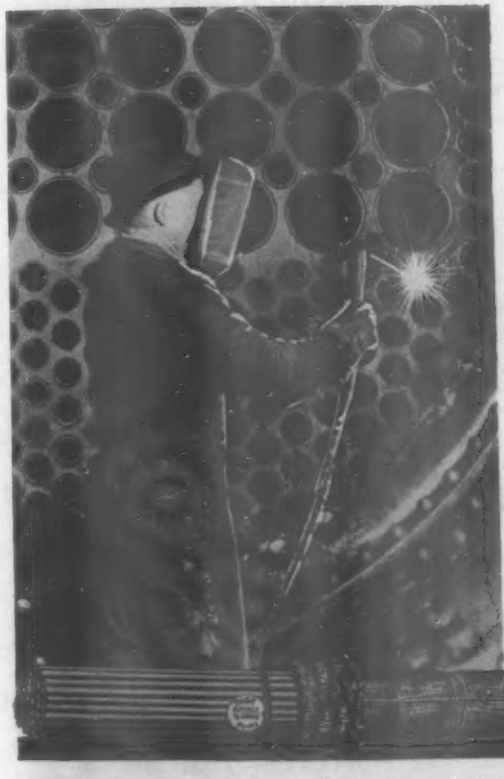

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at two points in service and would have to be scrapped were it not for the possible use of the gas welding process in repairing the cracks. As in th case of all complicated castings subjected to tension it is impossible to weld one section and have it cool off without causing internal stress. For this reason due allowance must be made for contraction in cooling and the careful annealing of all parts after welding is necessary to insure a permanent weld.

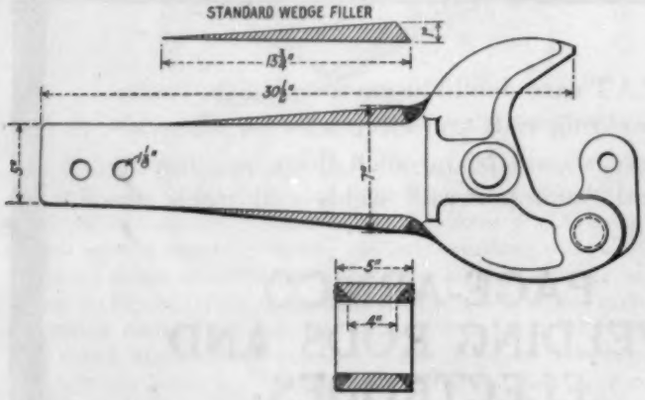


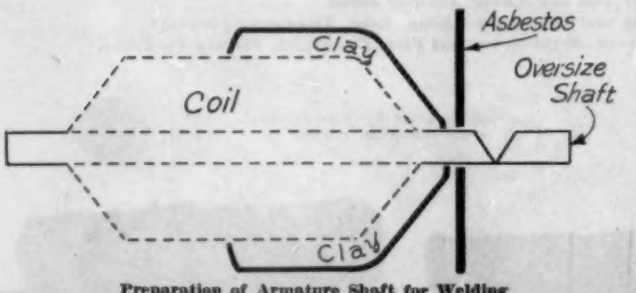
Fig. 18—The Addition of Wedge Fillers Changes 5 Inch by 5 Inch Coupler Shank to 5 Inch by 7 Inch; Gas or Electric

Another interesting example of welding is shown in Fig. 18 in which a 5 inch by 5 inch coupler is changed to a 5 inch by 7 by the addition of a standard wedge filler held in place by either electric or gas welding as shown in the illustration. One end and both sides of the filler are undercut as shown in the cross sectional view, the undercut space being filled in with welding material, thus holding the wedge filler firmly to the coupler shank. The preceding are but a few of the many interesting examples of welding work performed in modern railroad shops.

WELDING AN ARMATURE SHAFT

Editor:

From time to time I have noticed reference to the welding of armature shafts, so I think that a method of making these welds with the acetylene torch, which was recently used with great success, will be of interest to some of your readers. The heat was kept away from the coils of the armature by



Preparation of Armature Shaft for Welding

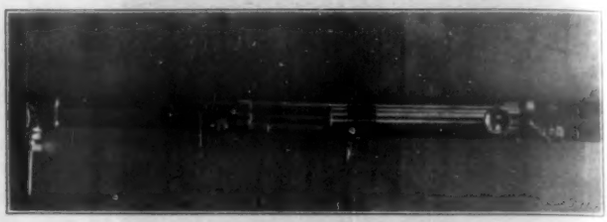
packing them in wet clay, making the clay packing heavy at the end of the shaft, where the break occurred. A large piece of asbestos paper was used as a shield, cutting a hole in the center of it just the size of the shaft and sliding it over the end right up to the clay. In repairing this particular shaft we made a brazing job of it, and machined it to size when the brazing was finished. The motor has seen daily service since being repaired in this fashion, and is apparently as good as new.

B. O. Warne.

NEW D-B CUTTING TORCH

The Davis-Bournonville Company has just brought out a new cutting torch, differing in design in several ways from the D-B standard cutting torch that has been on the market for several years. Two tubes instead of three connect the head with the handle, the preheating gases, oxygen and acetylene (or other combustible gas) being mixed in a chamber between the handle and the head. This change involves a new form of tip inasmuch as mixing of the preheating gases is accomplished before the gases reach the tip. The tubes are silver soldered in the head, which is a copper forging.

The ratio of mixed gases is controlled by two needle valves, one having a crossbar handle and the other a knurled disc handle. The cutting oxygen valve is operated by a finger



New Cutting Torch Has Two Tubes Instead of Three.

lever connected to a linkage so designed as to hold it in either the closed or open position. The operator using the torch may continue cutting without holding his finger on the trigger after the cut is started, as the linkage referred to holds it in the open position until such time as he wishes to stop the cut, when reverse pressure on the trigger closes the valve. The pressure of the spring holds it closed until the trigger is again pulled to the open position.

The construction of this torch is strong and rugged throughout although the weight is less than that of the previous model. Provision is made for easily removing the back end in case it becomes necessary to clean the screen or to renew the oxygen cutting valve seat.

NEW AIRCO BOOKLET

The Air Reduction Sales Company has issued a new catalog leaflet describing its Airco "D" Cutting Torch.

The leaflet completely describes the various features of design and construction of this apparatus, and in addition gives tables showing the thicknesses of metals that can be cut, the pressures of oxygen and acetylene necessary, and the gas consumption in cubic feet per hour when using tips adapted to the cutting of steel, cast iron or rivets.

The leaflet, which may be secured from any Airco district office, is illustrated by sectional views of the torch.

ACTIVITIES OF THE AMERICAN WELDING SOCIETY

A. M. Candy, Electrical Engineer of the Westinghouse Electric & Mfg. Co., addressed the Chicago section of the American Welding Society on the subject of "Commercial Application of the Electric Arc." The meeting was held on Friday evening, March 3rd.

The Pittsburgh section of the society convened on Friday evening, February 24th, to hear a discussion of the subject, "Welding of Stellite." H. A. Stewart, foreman welder of the National Transit Pump & Machinery Co., Oil City, Pa., delivered the lecture. The lecture included the welding of stellite by the gas, electric and brazing processes.

J. F. Lincoln, general manager of the Lincoln Electric Company, Clevelend, addressed the Cleveland section on the subject of "Carbon Arc Welding." The meeting was held on March 9th.

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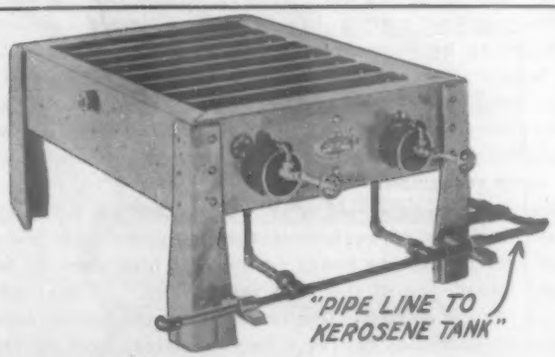

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Progress in Oxy-Acetylene Welding

Report of the Oxy-Acetylene Welding Committee of the International Acetylene Association

DURING the past two years there have been many advances in acetylene welding and cutting, and while in most cases these have not been radical, they have been of such a nature as to make the apparatus more reliable and successful in operation, which has resulted in the process becoming more economical and safer.

The theory of the operation of torches has become better understood with the result that back-firing has decreased, lessening one of the annoyances in the operation of the equipment.

There has been a general increase in the application of the processes, largely due to its application to war work which was continued after the war. Not the least notable accomplishment was that of the manufacturers of welding gases, who maintained prices during the war and after the war at very little increase over pre-war figures. This has enabled gas welding to compete in many cases with electric welding where otherwise, on account of low cost, the latter might have been used.

While there has not been any special increase in the size of pieces welded, there has been an increase in the number of such prices, due to the better education of those doing the work, and to the demonstrated success of large and difficult jobs previously done. And acetylene welding is coming to be recognized as a safe method of construction and repair when in the hands of good designers and skilled workmen. There has been much discussion of welding of important constructions, particularly with regard to large storage tanks for oil and pressure vessels.

Designs have been prepared for storage tanks having a capacity of 5,000 barrels, while somewhat smaller ones actually have been constructed and have proven their worth in service.

The pressure vessel situation is such that a code has been prepared for their construction by a Conference Committee on which your Association was represented. This code has been presented to the Boiler Code Committee of the American Society of Mechanical Engineers for their consideration, and in due time it will doubtless be a strong factor in the production of safe welded pressure vessels. This is one of the most important developments that has taken place during the last two years, if not the most important.

The welding of pipe lines has been extended very greatly, as it has been found that welded joints are more reliable than any other joint and cheaper than any other real good joint for permanent construction, as there is no chance for leakage. In one instance an 8-inch pipe line under very heavy pressure at all the joints welded, was tested to 1,000 pounds pressure, hydrostatically, and the welds were hammered with a sledge at that pressure. This pressure test has been found very successful in determining defective welds. The method is not new in some other fields, as for instance in the testing of cast iron and lap-welded pipe, but its application to welded construction generally is recent. Apparently it is just as effective as in the older cases.

Alloy Steel Welding: Study of this phase of welding indicates that metal of almost any desired composition can be deposited with the oxy-acetylene torch, but that there are many important problems like preheating, heat treatment and annealing to be considered.

Duriron, which is a high-silicon cast iron is being successfully welded, but must be most carefully preheated. Manganese steel is difficult to work, but good results are being obtained on simple castings.

The welding of alloy steels which are used where great strength is required, does not offer much promise, unless the metal can be poured and heat treated. Nickel steel, chromium steel, vanadium steel, etc., are splendidly welded, but as welds are almost always made where great strength of metal is needed at a point of maximum stress, further research in these lines is of importance.

Monel metal has been welded very satisfactorily for making acid containers and other vessels which must resist corrosion. Monel metal is also used for valves and other specialty work and welding is being studied in this connection.

Competition With Electric Welding: The oxy-acetylene welding is recognized by most users of all forms of welding, to be better in quality than electric arc welding. Where especially high quality welding is required and severe tests are to be passed, oxy-acetylene welding is being used almost to the exclusion of the electric process.

With oxy-acetylene welding a single butt-weld is considered the best practice and if properly made—which can be checked by test—will give complete satisfaction for any gauge of metal from the lightest to upwards of an inch in thickness. Latest practice in electric arc welding advises a lap-joint, thus making two welds, or the covering of a butt-weld by a double lap-welded strap. This latter practice is undoubtedly based on the lack of ductility of electric arc welds and means are, therefore, taken to keep the repeated stress off the essential butt-welds. It means three electric welds to one by oxy-acetylene, and also involves much extra material.

Oxy-acetylene cutting has been in a severe competition with cutting by oxygen used with substitute fuel gases. It has been very thoroughly determined that a large part of this competition has been due to the difficulties of obtaining compressed actylene during the war and immediately following. The efficiency of acetylene in this connection is being more and more recognized.

Heavy cutting is a field where the process has been limited by the inability of equipment to supply sufficient oxygen. Some very interesting heavy cutting has been done by using special knowledge of the need for oxygen. In one case 27 feet of 15-inch steel was cut in removing the hollow circular riser of an enormous casting. Two regulators were connected on the reduced pressure side, and the oxygen was led through a large hose to the torch. In a case at the Philadelphia Navy Yard, Mr. Grow, assistant shop superintendent, connected five regulators to a common low-pressure pipe, 2 inches in diameter, then he used an air hose to carry the oxygen to the blowpipe, which had a specially large tip. The oxygen bore was ¼ inch in diameter. By this means and by increasing the oxy-acetylene preheat a little, he made beautiful cuts 24 inches by 24 inches.

One of the expert cutters of an apparatus company successfully cut through 34 inches of steel, and one user of the process reports the cutting off of a 44-inch square riser by use of a regular torch. The cut in this case was not straight through, but accomplished the result.

Oxy-acetylene cutting has been used for constructive work very much during the past two years. Forgings have been trimmed practically to dimension, and in some cases cutting has been so developed that as intricate shapes such as connecting rods are being cut out with the oxy-acetylene torch. Some very interesting work has accompanied this constructive cutting.

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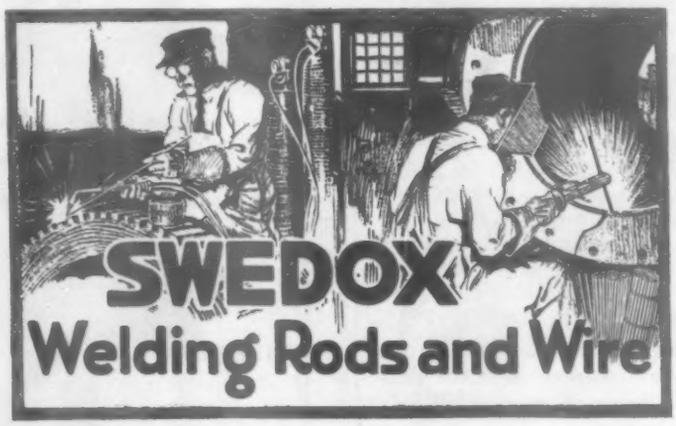

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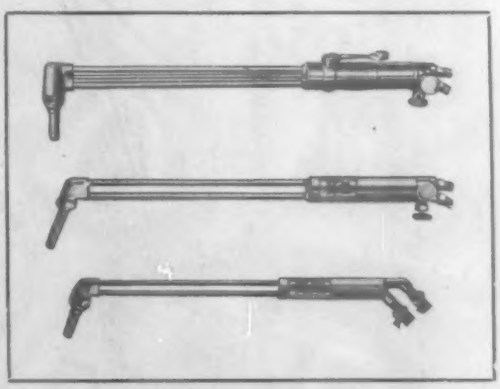

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Mr. McElvain uses the No. 7 and 8 Hauck double burner preheater, described in bulletin No. 127; copy mailed upon request.

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Cast iron cutting is an extremely interesting development of the past several years, with the real service work limited to the past two years. The fundamentals of the process seem to be that a large excess of preheat must be used, so that the cast iron is heated to a red temperature over a considerable space. A large and powerful oxygen jet is then directed on the red-hot cast iron, with the heavy preheat still being continued. The kerf made in the iron casting is quite similar to that made in cutting of steel, except that the width of the kerf is generally double that in a similar sized steel casting and is not quite so clean looking. It is easy to see that more gases are used than in similar steel cutting, and it has been noted in tests that the time for cutting is about double that in the case of steel; therefore, cast iron cutting is three or four times as costly as steel cutting and in normal work it can hardly be said to compete with saws. There are, however, many places where heavy chamfer cutting is to be undertaken and a couple of welders are standing by. Normally the cast iron would be "V'd" out by a laborer with compressed-air-driven tools, and probably a day or two would be required for preparing a large job. Although cast iron cutting is more expensive than is the actual preparing of the work by compressed-air tools it is certainly very economical in the above case when we consider that two operators must stand by at an expense of $10 to $15 a day each.

An interesting and very valuable use of oxygen is the burning of holes into salamanders in blast furnaces, to permit the insertion of the dynamite used in breaking them up. A similar process is used in opening furnace tap-holes. This is done by heating the point at which the hole is desired to a red heat and directing against it a steel pipe through which oxygen is passed under a very heavy pressure, often up to 250 pounds. The burning of the steel pipe brings the cast iron to a temperature for the oxygen to combine with it. Of course, the steel pipe is gradually burned away; but the hole may be made of almost any depth by supplying sufficient pipe and oxygen.

Oxygen manifold and pipe-line installations have been recommended together with the use of cylinder platforms. The use of platforms enables cylinders to be unloaded from trucks and reloaded without a large labor party being called. Cutting down on the problems of cylinder handling helps stabilize the industry by removing an annoyance. In large installations for welding and cutting, such as are done at some of the steel mills, improved means of handling oxy-acetylene tanks and carbide have been introduced and safety rules provided for their storage and handling. These improvements and rules have resulted not only in rendering the process more economical, but they have decreased accidents. Safety rules should be advocated by all those interested in the acetylene process and their adoption should be urged upon all users regardless of their size. One of the interesting developments is the use of automatic machines for welding tubing from strip steel the product being far equal to seamless tubing and costing much less.

The problems confronting our industry are many and varied. It is gradually being found out that welders cannot be made in six weeks, except for the simplest operations; and, while there is not complete agreement as yet on the best methods of training welders, the work is being gradually crystallized and the condition will improve rapidly as soon as those vitally interested appreciate the need of proper and thorough training, not only in the actual handling of the apparatus, but in the fundamental principles involved. When this time comes welders will be selected intelligently instead of haphazardly, as is too often done at present. Your committee urges on the members who are interested that they give this phase of our problems special attention.

During the last two years considerable progress has been made in the study of the fundamental problems of gas welding, such as the best quality of welding wire, the necessi for satisfactory quality of steel plate for welding, and oth problems which are strictly research matters. Such proble cannot be solved in a short time. There are many fact involved, not the least of which is the necessity of provi to those who make the wire and plate that their product mu be of satisfactory quality aside from its chemical compos tion, if good welding is to be secured.

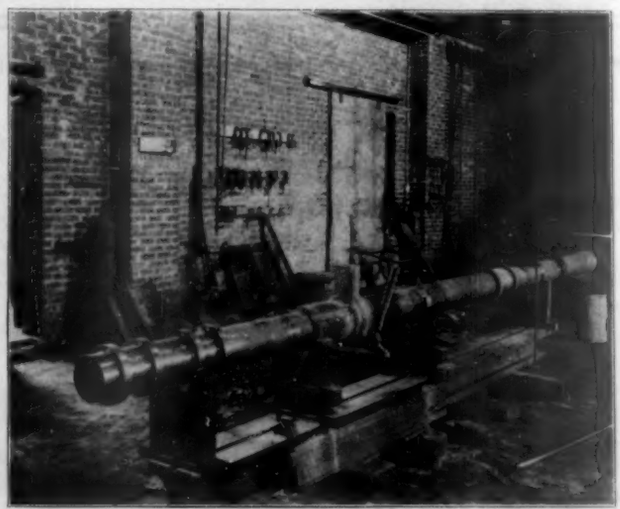
Already progress has been made in this direction, but muc remains to be done. Your committee hopes that active c operation of the members may be secured in furthering thes very important matters.

Research on the proper composition of welding wire seem to show that ordinary straight carbon steel is not the bes metal for the purpose, but that alloy steel of the proper com position should be used if the best results are to be obtained. This is very important and the subject requires a large amount of experimenting, but there is no question that the better results may be expected within a reasonable time.

PREHEATING LEADS TO SUCCESSFUL THERMIT WELD

Editor:

In the accompanying photograph is shown a large shaft which was recently welded by the Thermit process. This shaft belongs to a hydroelectric power plant generator of 3,750 K. V. A. capacity and driven by 110-foot head on two bronze runner wheels. It is running in a horizontal position of 360 R. P. M., 24 hours per day since May, 1921. Dimensions are 9¼ inches (largest diameter) by 20 feet 4 inches long.



A Thermit Weld Which When Completed Showed Almost Perfect Alignments

What we think is remarkable about this job is the fact that when placed in the lathe we found that it was out only ¼ inch which was due to shrinkage of riser. And by springing we were able to make it run so true that it was not necessary to turn any of the bearings. Also, it came back to exact length. We attribute all this to being properly equipped for this kind of work and to careful alignment. By using care and proper materials in making the mold and by heating to a good cherry red before running the Thermit steel, we produced a weld of which the structure was first class after turning off the collar. This is only one of the several heavy Thermit welds we have made in the past six years, and we have never lost a weld.

C. E. Kimball.

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- 1 7-in. Wrench.
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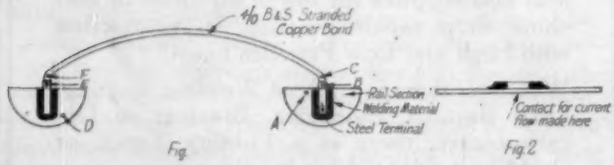
CONTACT RESISTANCE OF 4/0 ARC WELDED BONDS

By H. M. Gould*

A 4/0-66" arc welded cross bond which was installed at Shoemaker and Lillibridge streets, Detroit, December 6, 1920, was recently removed because of a change in the track layout and tests were made on this bond to determine the resistance between the terminals and the rail through the welding material and also to determine the contact resistance between the copper cable and the steel terminals.

The method of making the test was as follows:



Figs. 1 and 2. Diagram of Bond Test

Current was passed through the bond and rail sections by clamping the terminals of an electric circuit on the rail sections on the side opposite from which the terminals of the bond are welded, that it at the point indicated in Figure 2. This allows a uniform current flow from the rail section through the welding material to the steel terminal on the bond or vice versa depending on the direction of the current.

Potential drops were then taken between points A (on the rail suction) and B (on the steel terminal), also between points B and C. Likewise potential drops were taken between points D and e, and E and F. These connections were made

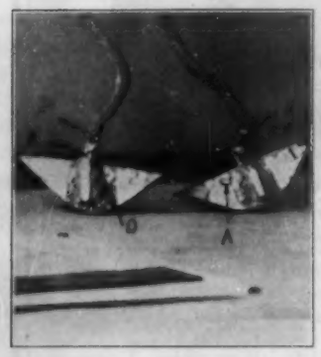


Fig. 3

Fig. 4

by means of wires soldered on at the various points shown in Figures 1, 3 and 4.

The results as obtained by the Detroit Testing Laboratory, a copy of whose report is attached, were as follows:

	Temp. Deg. F.	Volts Drop	Current Amps.	Resist. Ohms	I^2R Loss in Watst
Steel Terminal to Rail A to B	68	.00161975	80	.000020246	.12957
Steel Terminal to Copper Cable B to C	68	.000995	80	.00001243	.07955
Steel Terminal to Rail D to E	68	.001127	80	.000014087	.090156
Steel Terminal to Copper Cable E to F	68	.0007125	80	.000008906	.056998

* *Electrical Engineer, Detroit Street Railways.*

No. 2415--2
Sample from—City of Detroit, Dept. of St. Rys. Date—12-1--21
Sample of—Rail Bond Welds Customer's Order—Mr. G--ld
Remarks— D. T. L. Order 1--89

Sample No.	Temp. ° F.	Volts Drop	Current Amperes	Resistance Ohms	I^2R L-ss in W--ts
1—Bond to rail	68	.00161975	80.0	.000020246	.129-7
2—Wire in Terminal	68	.000995	80.0	.00001243	.07- 5
3—Bond to rail	68	.001127	80.0	.000014087	.09- 56
4—Wire in Terminal	68	.0007125	80.0	.000008906	.05- 98

REMARKS—
1—One end of bond weld.
2—One end of bond.
3—Other end of bond weld.
4—Other end of bond.

THE DETROIT TESTING LABORATORY

Detroit, Michigan

It is, of course, not possible to give the conductivity as compared with pure copper since the section of bond surface has but two dimensions; no thickness.

The results given in I^2R loss show conclusively that the resistance in the weld at one end is only about twice the resistance of the joint between the wire and the welding terminal, while at the other end of the bond the resistance in the weld is about one-half greater than the resistance in the joint of the wire and the welding terminal. Also a variation in the resistance of the two terminal connections and the wires is found to exist which is almost equal to variation in the resistance in the weld. The losses are so insignificant that we may rightly assume the connection to be electrically perfect.

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It is a well-known fact that particularly in production work where the torch is employed, intermittently, considerable gas and operator's time may be lost by either burning the gas while operator moves the work, or through relighting.

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NEW ARC WELDING INSTRUCTION BOOK

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The subject matter in the book is confined to autogenous electric arc welding and no attempt has been made to cover electric welding in its broadest sense. The book covers descriptions of welding systems and their installations, phenomena of the metallic and carbon welding arc, training of operators, methods for applying metal to various types of joints and building-up operations, electrode materials used, weldability of various metals, weld composition, thermal disturbances of parts affected by the welding process, physical properties of completed welds, efficiency of welding equipments, welding cost, etc.

This information is that which is most in demand for practical purposes, and the book is one of the unusual books that covers a scientific subject without the aid of mathematics. It should be found useful both as an instruction book for teaching the layman the underlying principles of welding processes and as a convenient reference book for the welding operator.—254 pages, 167 illustrations. Size 5 in. x 9 in. Bound in cloth. Published by Simmons-Boardman Publishing Company, Woolworth Building, New York.

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Wanted—Six W. C. and four W. K. Prest-O-Lite agreements. Address 28, care The Welding Engineer.

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Current Welding Literature

HOLE BORING EXTRAORDINARY—Drilling holes in furnace skulls (weighty lumps of mixed metal and slag) preparatory to breaking them up with explosives, is accomplished by placing a hanuful of small coal at the point where the hole is desired, connecting a fourteen foot length of quarter-inch gas pipe to an oxygen cylinder, using a length of armoured tubing for the connection, turning on the oxygen and setting fire to the end of the gas pipe, then directing the oxygen jet on the cold coal. A perfectly round hole is rapidly blown into the block.—Industrial Gases, London, December.

THE MAKING OF JOINTS IN SEAMLESS STEEL TUBING, by C. N. Waterhouse—Wartime developments in Aeronautics have brought into prominence the problem of making joints in steel tubes. In this paper, read at a meeting of the British Acetylene and Welding Association, the various methods of making such joints are discussed. It is pointed out that screwed joints proved a failure, brazing has strength limitations, pinning is slow and costly, so a combination of pinning and soft soldering was proposed. The strength of joints produced with solders of different composition is given, with some discussion of the action of fluxes. —Acetylene and Welding Journal, London, January.

THE CYC-ARC PROCESS OF AUTOMATIC ELECTRIC WELDING, by L. J. Steele—Technical description of process and apparatus used in welding small screws or studs to ships' plates to carry the supporting clips of electric cables and other fittings. The method consists in the formation of an electric arc between the metal studs and the body into or on which the stud is to be welded, maintaining the arc and current for a suitable length of time, the period of which is automatically controlled, and subsequently, but before interrupting the flow of the main current, forcing the molten stud end against the molten metal body by electrically or mechanically actuated means.—Journal of the Institution of Electrical Engineers, London, January.

USE OF PREHEATING TORCH FOR REPAIR WORK, by J. H. Clemmency—In addition to preparing jobs for welding the portable preheater can be put to effective use on a variety of odd jobs, such as: straightening bent parts of machinery; loosening parts that have corroded together; removing babbitt metal; and heating rivets.—Machinery, March.

PRACTICAL POINTS IN ARC WELDING, by J. A. Wilson—A practical discussion of the welding operation from the point of view of the welding foreman. The points especially emphasized are: keeping the work clean, beveling the edges, allowing for expansion and contraction, guarding the workman against injury, and making solid welds. Overhead welding is a matter of correct manipulation of the electrode, so that the length of the arc is kept constant.—American Machinist, March 9.

WELDING AS APPLIED TO BOILERS AND OTHER VESSELS, by E. R. Fish—Abstract of paper read before American Boiler Manufacturers' Association. The mutually antagonistic attitudes of proponents of various types of welding develops discussions which lead the author to conclude that those who think they know all about it do not themselves know very much about it. One of the principal considerations which he sees is that the welded part is not homogeneous, and has not the same characteristics as the plate.—Iron Age, March 2.

BOILER WELDING, by E. H. Heidel—A list of the allowable welds on locomotive boilers, with instructions and diagrams. From a paper read before the American Welding Society, Chicago Section.—Acetylene Journal, March.

SCRAPPING THE BATTLESHIPS, by J. B. Walker—Torch replaces cold chisel in converting a fleet to junk. Details of the amount of this work that remains to be done show that nearly 200,000 tons of steel scrap and 4,000 tons of brass scrap will be obtained from seventeen battleships which are to be broken up.—Acetylene Journal, March.

HOW WELDERS PLAY VITAL ROLL IN NORTHERN RAILWAY SYSTEM, by A. G. Rubbra—Brief discussion of some instances where worn out equipment, formerly scrapped, is made good as new by welding.—Canadian Welding Journal, February.

SUCCESS DEPENDS ON WELDING RODS, by F. A. Grimmer—Quality of weld is directly affected by choice of rod and proper manipulation.—Canadian Welding Journal, February.

SAFETY IN OXY-ACETYLENE WELDING—Rules which may well be observed by all who are welders and those who have care of oxygen and hydrogen tanks, as adopted by the Western Pennsylvania Division of the National Safety Council.—Canadian Welding Journal, February.

OXY-ACETYLENE PRESSURE WELDING, by A. S. Kinsey—Source of heat supply important in welding; physical characteristics of oxy-acetylene welds; most serviceable medium for welding; welding pressure tanks; welding pipe and pipe mains; welding cast iron cylinders. The paper is general in nature, dealing more particularly with the advantages of the process than with details of operation.—Ice and Refrigeration, December.

SUBMARINE CUTTING TORCH UNDER WATER, by R. G. Skerrett—History of the development of submarine cutting, leading up to the use of an electric torch for cutting off a broken siphon pipe 50 ft. under water.—Iron Age, March 9.

LACK OF SUCCESS IN THE WELDING OF ALUMINUM—The susceptibility to corrosion of aluminum which has been heated to welding temperature, leads to the investigation of what happens when a small percentage of copper is mixed with the aluminum. It is found that when one per cent of copper is added the resistance of the weld to corrosion is equal to the resistance of the parent metal.—Revue de la Soudure Autogene, January.

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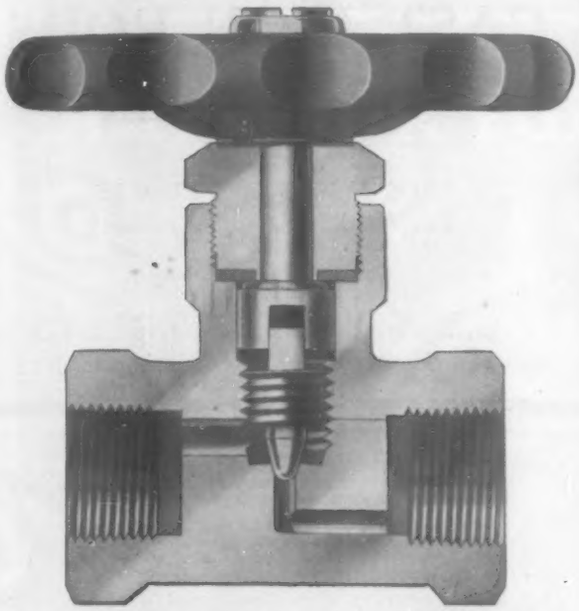

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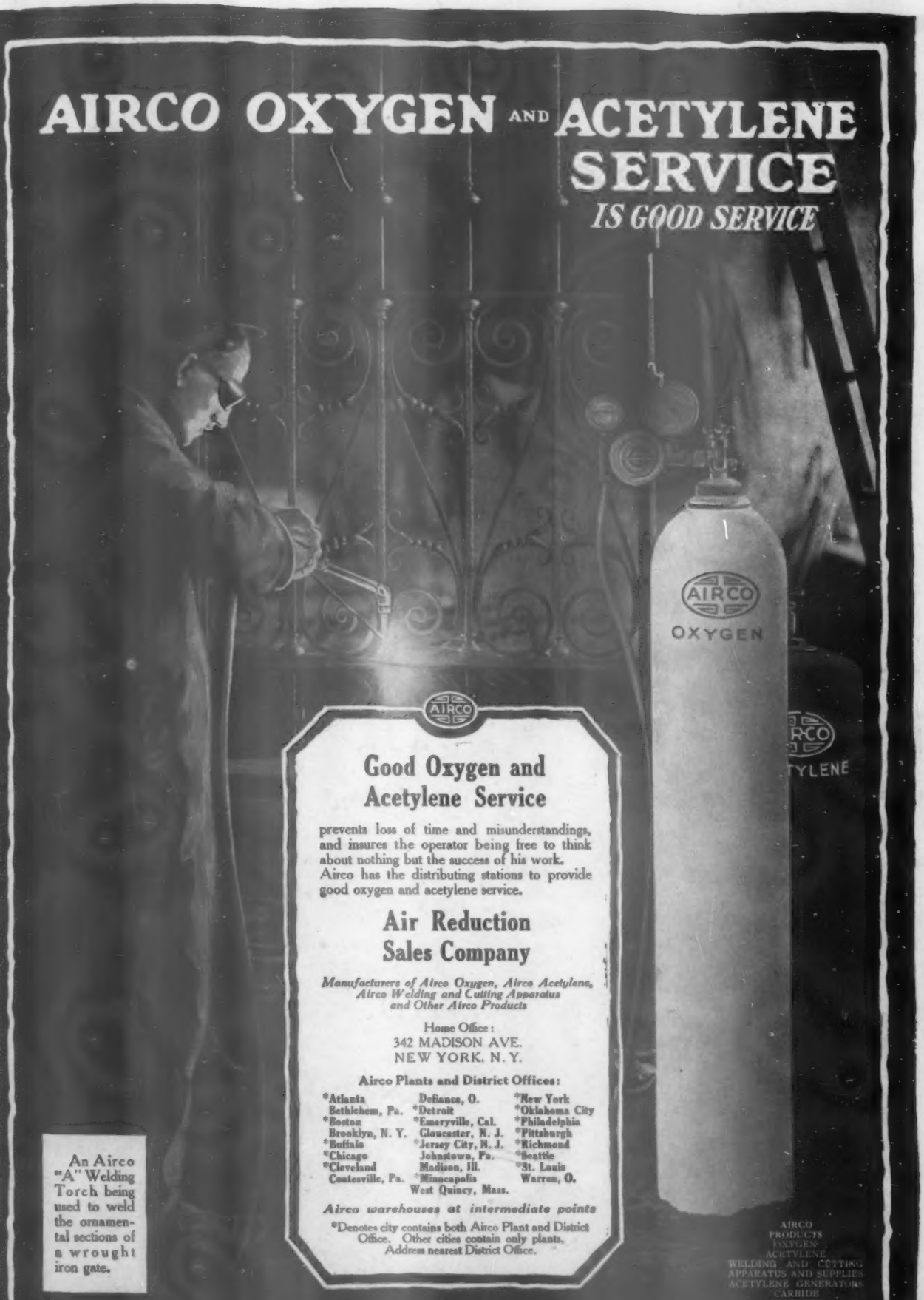

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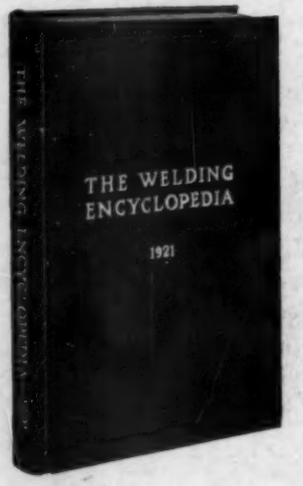

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